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VALPARAISO UNIVERSITY
DEPARTMENT OF ENGINEERING

FIELD MANUAL
FOR
PLANE SURVEYING
AND
RAILROAD CURVES

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PREFACE

This book is intended to be used supplementary to Class Room lectures, Assigned Reading in a Standard Text and Field Instructions.

It contains sample field notes to fundamental problems or exercises, so arranged as to give correct form of notes, and concise information for the solution of the problems. Blank pages immediately follow each problem for the record of the solution of a similar problem by the student.

This manual is a product of the teaching staff of the Department of Engineering.

R. C. YEOMAN.
E. A. TUCKER.

INTRODUCTION

The theory of Plane Surveying is surprisingly simple to the well prepared, but the successful application of this knowledge comes only from long and continued experience and the development of good judgment. In a college course it is impracticable to spend this necessary time, therefore, the aim is to familiarize the student with the use, care, and adjustment of instruments, the solution of the problems involving their use, and the methods of recording the acquired data in a clear and concise manner.

GENERAL INSTRUCTIONS

It is an observed fact that students are usually very careless in the care of instruments and apparatus. An instrument should be treated ***kindly,*** for their parts are of soft metal, and it is very easy to strain the instrument by forcing the adjusting screws. The heads of the thumb screws on the instruments give a leverage out of proportion to the strength of the screw thread, thus they are quite easy to strip. All movable parts are made to a snug fit, and should work easily.

If the adjustments are either tight or loose, the instrument needs attention, and the instructor in charge should be notified. Further cautions are given in the texts and class-room.

At Valparaiso University the instruments are kept in numbered lockers. A list of the contents of each locker is found on a card on the inside of the

door. To obtain the use of any apparatus the applicant must sign a requisition slip for the key to the locker. The applicant then becomes responsible for all apparatus in the locker until the key is returned and locker checked. After use, every piece of apparatus must be returned in good condition to it's place. A penalty is attached to any neglect in this particular.

As related in the preface, the instruction in this book is given in form of actual field notes. It is not intended that the student should follow them literally. They are given only as a guide to good practice. In the higher branches of surveying the forms are not given, they must be made up by the student. He will by that time be familiar with correct forms, and can easily plan his notes to suit the particular problem in hand.

Field notes should be made in their final form in the field. The practice of putting them on small bits of paper and transferring them in the office or room leads to many errors and lost data.

The student whose note book shows lack of skill in the beginning need not be discouraged as this is only natural. It is the improvement which counts, and the notes should show it.

Accuracy should be the chief aim of all surveyors. When the results do not come within the permissible error, many beginners are tempted to fudge their notes. Fudging is an indication of laziness and dishonesty, and is easily detected. It is better to repeat the survey several times and fail, than to sacrifice honesty,—the greatest virtue of the Engineer.

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DETERMINATION OF

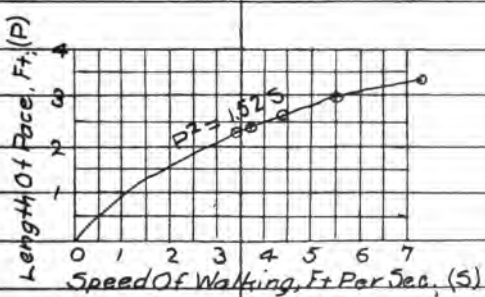
KIND OF PACE	PACES PER 400 FT. NO PACES	MEAN PACES	LENGTH OF PACE, FT	REMARKS. Smooth Ground
Natural 1	157.			
2	156.			
3	156.3			
4	155.5			
5	155.0			
6	155.5			
7	157.0			
8	154.0			
9	155.5			
10	156.0	155.8	2.56	
3 Foot 1	134.5			
2	133.5			
3	133.2			
4	134.1			
5	133.0			
6	134.0			
7	133.3			
8	134.0			
9	133.5			
10	133.0	133.6	2.98	

MAR. 10, '11 (2 HRS) Clear And Warm. T. BROWN
SURVEYOR.

LENGTH OF PACE

EFFECT OF SPEED ON LENGTH OF PACE.

KIND OF PACE	PACES IN 400 FT. OBSERVED PACES	MEAN PACES	MEAN PACE (P) FT	TIME 400 FT. SEC.	SPEED OF PACING, (S) FT. PER SEC.
Very Slow	165.5				
" "	168.0	166.57	2.41	120	3.33
Slow	162.0				
"	164.0	163.0	2.45	110	3.63
Natural	154.0				
"	156.0	155.0	2.58	90	4.44
3-Foot	133.0				
"	133.3	133.15	3.0	73	5.45
Fast	126.5				
"	126.3	126.4	3.16	54	7.4



STAKING - OUT

The polygon A-B-C-D-E was located by means of hubs driven flush with the ground, in centers of which were driven a tack.

Each hub was described as follows:-

Point (A) is 3' east of seventh post in the west fence of University Park

Point (B) is 6' south of southeast corner of east Tennis Court

Point (C) is 3.5' east of fourth post south in east fence of U.P

Point (D) is 5' north of north-west corner of Grand Stand

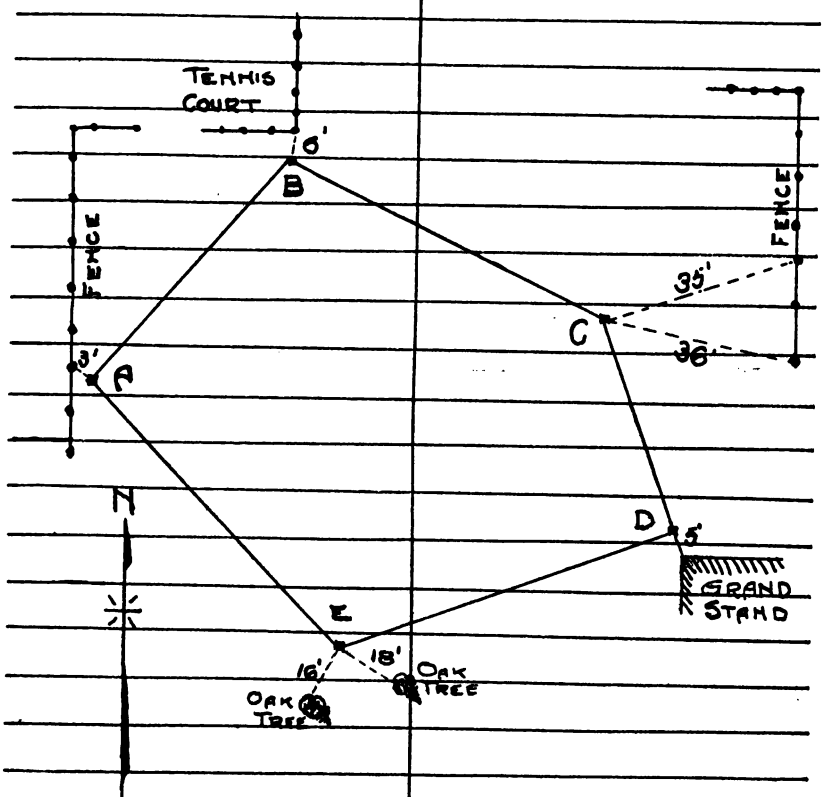
Point (E) is 16' and 18' north of two most northerly blazed oak trees.

All distances were paced.

T. BROWN 2.
SURVEYOR.

A - POLYGON.

March 12, 1912. (1½ HRS) Cloudy and Cool.
Used axe, flags, hubs, and tacks.



SURVEY OF FIELD

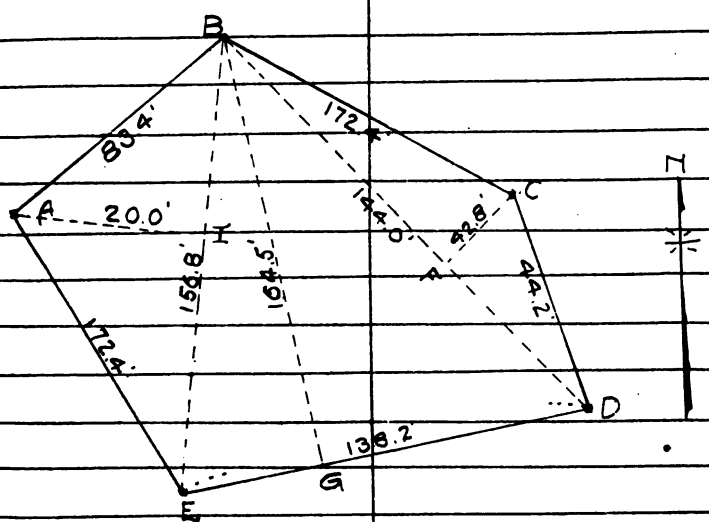
LINE		LENGTH OF PACE		LENGTH OF LINE		
	No.	PER 400 FT.	FT.	OBSERVED PACES	MEAN PACES	LENGTH FT.
AB	1	140		29.5		
	2	139		29.7	29.6	84.3
BC	1	141	2.85'	60.0		
	2			60.0	60.0	172.4
CD	1			15.5		
	2			15.5	15.5	44.18
DE	1			48.5		
	2			48.5	48.5	138.2
EA	1			60.0		
	2			60.0	60.0	172.4
BE	1			57.8		
	2			57.6	57.7	164.5
BD	1			52.2		
	2			52.5	52.3	144.0
CF	1			15.0		
	2			"	15.0	42.8
BH	1			55.0		
	2			"	55.0	156.8
AG	1			7.0		
	2			"	7.0	20.0

T. BROWN.
SURVEYOR

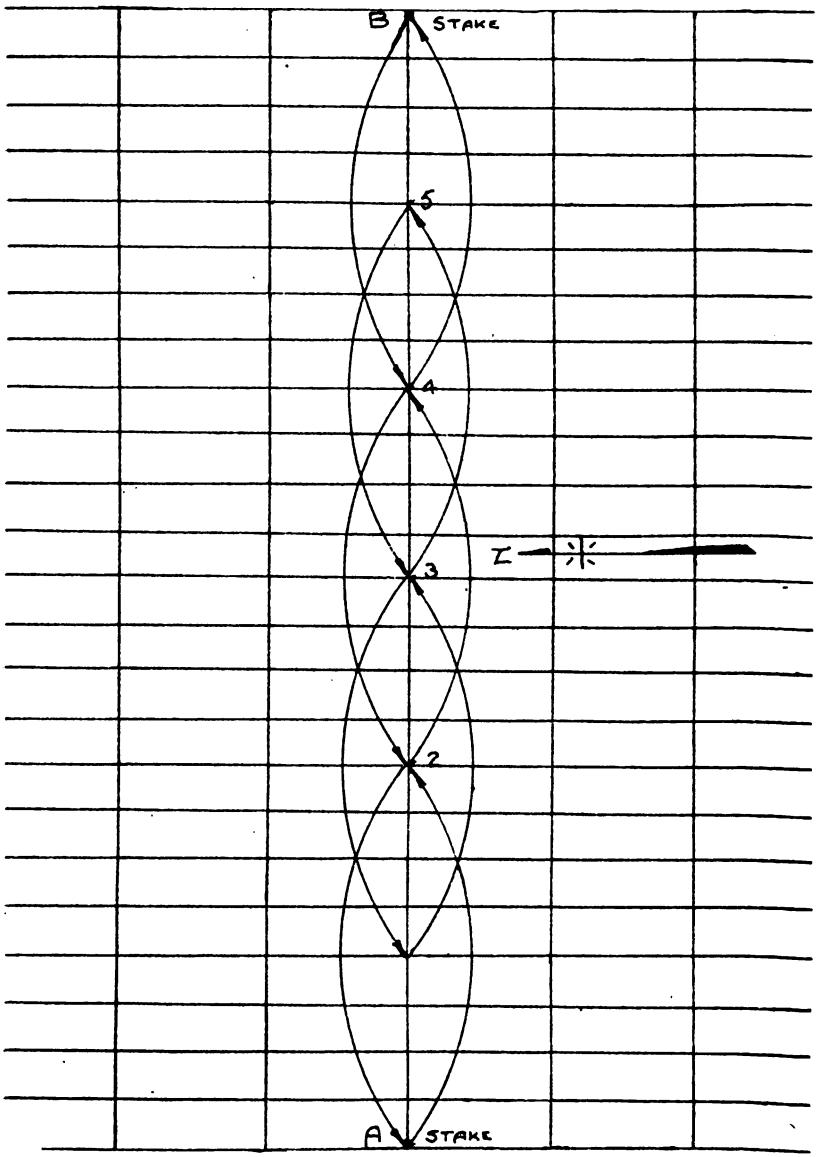
-BY-PACING

March 13, 1912 (2 HRS) Clear and Windy.

The sides, diagonals, and altitudes of polygon A-B-C-D-E were paced twice. This data is sufficient to calculate the area by two methods, thus affording a check.



PROLONGING-A-LINE-.



-BY-MEANS-OF-FLAG-POLES.

March 14, '12. Cold, ground covered with snow.

Used four flag poles.

Flag poles were placed at points A and B approximately 600 feet apart. A third pole was then located at point (1) in line with (A) and (B). The pole at point (B) was then removed.

Another pole was placed at point (2) in line (A-1). The flag at A was then moved to (3) in line 1-2. Thence pole at (2) was moved (4) in line 2-3. This operation was repeated until point B was reached, and the error of alignment was found to be 0.1 feet.

The same operation was repeated returning to point A from B and error was 0.15 feet.

Then operation was again repeated up and back, usig 200 foot distances instead of 100' distances. The error was found to be 0.2' feet.

The operation was repeated using 300' distances instead of 200' distances. Error was found to be .25'

MEASURING-A-DISTANCE-

LINE	DIRECTION CHAINED	OBSERVED LENGTH	DIFF. OF TOTAL	RATIO 1:d	COEF C:
C		FT.	FT		FT
TAPE	Before	100.00			
"	After	100.00			
A-B	N.	236.564			
B-A	S.	236.542	.22	1:10720	
		$E = C\sqrt{L}$,	$C = \frac{E}{\sqrt{L}}$	$E = .22$, $L = 23.65$	
					$C = .045$

T BROWN, HEAD CHAIN.
J. JONES, REAR CHAIN

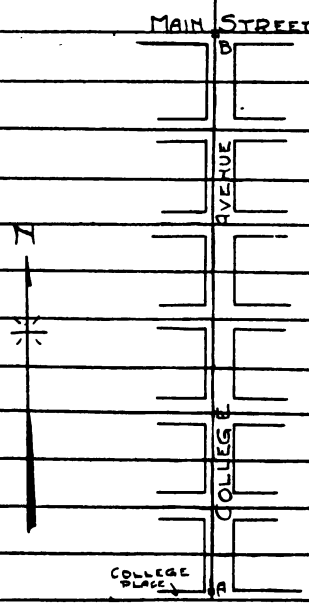
WITH-100-FT.-STEEL-TAPE

March 15, 1912 (2 HRS) Clear and Cool.

Used 100' steel tape, plumb pins, and kiel. Locker #25

Before commencing work the tape was compared with standard, using spring balances with 12# pull.

Chained along west side of College Ave 5' feet from curb line. Tape was held horizontal, plumbing down if necessary. The tape lengths were marked on brick pavement, by means of kiel. Tape being graduated into tenths, hundredths of feet were estimated. The distance was rechained to place of beginning.



CHAINING ON SLOPE BY DIRECT

NO.	OBSERVED LENGTH FT	DUPLICATE MEAS.	MEAN LENGTH FT	RATIO 1:d	COEF. C.
TAPE	100.00				
1.	52.0				
2	57.0				
3	100.0				
4	31.0				
5	41.0				
6	25.0				
7	18.0				
8	15.0				
9	16.0				
10	16.0				
11	17.0				
12	18.0				
13	24.0				E=.09
14	35.0				$C=\frac{.09}{\sqrt{6.31}}$
15	96.0				
16	99.62				C=0.36'
	630.62	630.51	630.56	1:7600	

J. JONES, HEAD CHAIN
T. BROWN, REAR CHAIN

6-A

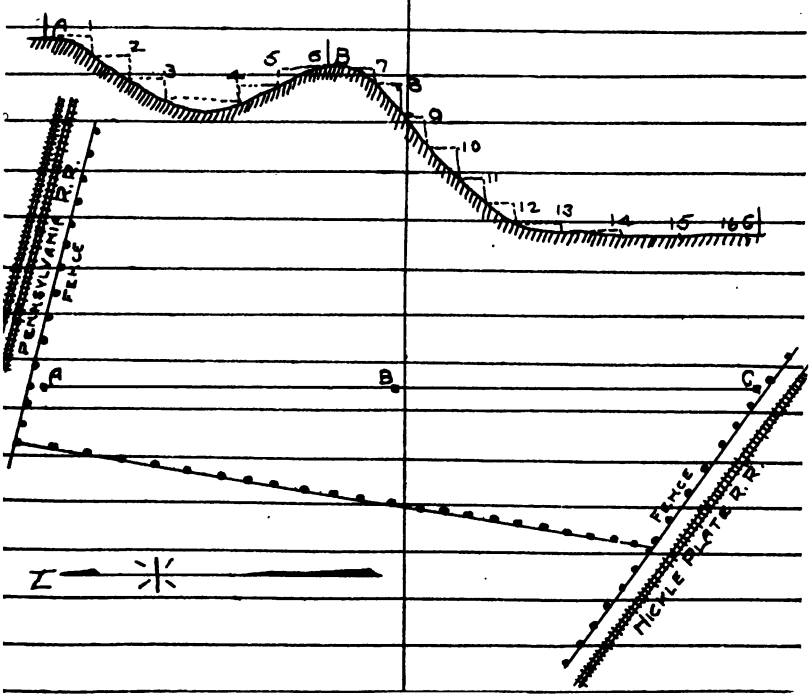
HORIZONTAL MEASURMENT.

March 18 1912 (2 HRS) Clear and Moderate.

Used Locke's Hand level, 100' Steel Tape, chaining pins, plumb pins, and range poles.

Three points A, B, C were located in a straight line, with a flag pole at each point.

In chaining the rear chainman lined in head chainman who retired down slope a such a distance as was convenient to plumb down. The tape was made horizontal by means of level. In chaining up slope the process was reversed.



CHAINING-ON-SLOPE-BY-MEAS-

No.	c	a	a^2	b	
1	47.10	4.7	22.1	46.9	A
2	43.7	4.5	20.3	43.5	
3	59.6	2.2	4.8	59.55	
4	54.2	4.5	20.3	54.0	
5	28.7	5.0	25.0	28.3	
6	37.4	3.7	13.7	37.2	B
7	26.3	4.5	20.3	25.9	
8	17.5	4.6	21.2	16.9	
9	15.6	4.7	22.1	14.9	
10	14.7	4.8	23.0	13.9	
11	15.7	4.8	23.2	15.0	
12	14.5	4.6	23.2	13.8	
13	17.7	4.8	23.2	17.05	
14	19.6	4.6	21.2	19.1	
15	19.2	4.6	21.1	18.65	
16	30.1	4.7	22.2	29.2	
17	68.7	1.8	3.2	68.68	
18	96.0	0	0	96.0	
19	11.7	0	0	11.7	C
				630.73	

T BROWN, HD. CHAIN.
J. JONES, RR. CHAIN.

6.
B.

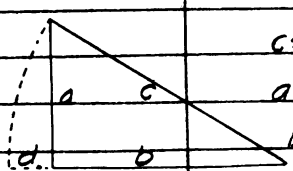
UREMENT-ON-THE-SLOPE.

March 19, 1912. (1½ HRS) Fair and warm. Locker #18

Used Locke's Hand Level, 2-5ft graduated rods, steel tape, chaining pins, plumb pin and flag poles.

The same distance was chained as in previous problem, except measurements were taken on slope.

The chainmen were each provided with 5ft graduated rods. The head chainman retires down the slope a distance such that the horizontal line of sight from the top of his rod strikes near the bottom of the other rod and the tape reads some even number of feet. He then take the reading on the rod and computes the differene in elevation between the ends of the tape. From these two measurements, the measurement on the slope is reduced to the horizontal.



c = Meas. on slope
a = Diff. in elev.
b = Reduced hor. dist.

$b = c - d$

$c^2 = a^2 + (c-d)^2$

$c^2 = a^2 + c^2 - 2dc + d^2$

$d^2 - 2dc = -a^2$

$d(d-2c) = -a^2$

$d = \frac{-a^2}{d-2c}$

$\therefore d = \frac{a^2}{2c}$ (App)

MEASURING - ANGLES -

STATION	TRIGONOMET. FUNCTION NAME	VALUE	COMPUTED HALF	ANGLE WHOLE	MEAN ANGLE
E	SIN ½ E	.8955	63° 35'	127° 10'	127° 10'
A	SIN ½ A	.2165	12° 30'	25° 0'	
"	TAN A	.4700		25° 11'	25° 5.5'
D	SIN ½ D	.2385	13° 48'	27° 36'	
"	TAN D	.5300		27° 55'	27° 45.5
					180° 01'
			Error of Closure =		
			Permissible Error =	3	

Assigning equal weight to the three results, the most probable values are

ANGLE E = 127° 9' 40"
" A = 25° 5' 10"
" D = 27° 45' 10"
180° 00'

WITH-A-STEEL-TAPE.

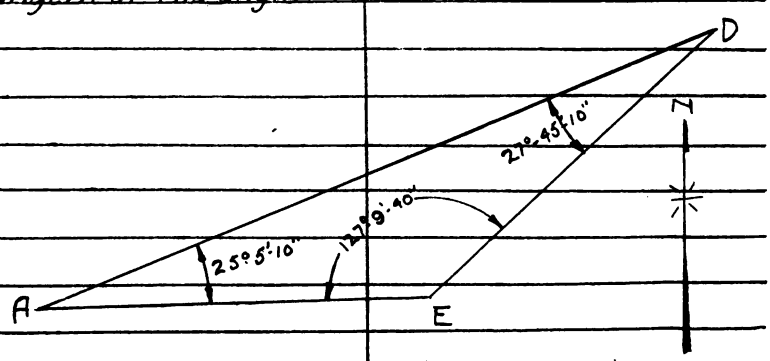
March 22, '12 (2 HRS) Clear And Windy.

Used 100' steel tape, chaining pins and poles. Locker #22

The angles of a triangle were measured by two methods, the Chord Method and the Tangent Method.

In the Chord Method a radius was struck off using the vertex of the angle as a center, on the adjacent sides of the angle. The chord joining the extremities of these radii was measured. The ratio of half this chord to the radius equal the natural sine of half the given angle.

In the Tangent Method a perpendicular was erected to one of the adjacent sides, by the 3-4-5 Method, until it intersected the other adjacent side. The ratio of this perpendicular to distance from foot of perpendicular to vertex of angle equals the tangent of the angle.



SURVEY FOR AREA OF FIELD

ANGLE	TRIG FUNCTION				
	NAME	VALUE	COMPUTED ANGLE		MEAN
			HALF	WHOLE	
AEB	SIN ½ AEB	.3570	20°55'	41°45'	
	TAN "	.8900		41°41'	41°43'
BEC	SIN ½ BEC	.2964	17°15'	34°30'	
"	TAN "	.6850		34°25'	34°27'
CED	SIN ½ CED	.4320	25°36'	51°12'	
"	TAN "	1.2460		51°15'	51°13'
LINE	OBSERVED LENGTH FT.	LINE	OBSERVED LENGTH FT.		
A-B	73.10	E-d	49.90		
B-C	62.65	C-d	57.85		
C-D	78.82	B-b	61.80		
D-E	69.59	C-b	9.03		
E-A	76.40	E-b	91.75		
E-B	109.20				
A-a	50.95				
E-a	56.85				
B-a	52.48				
E-C	100.80				
D-d	54.10				

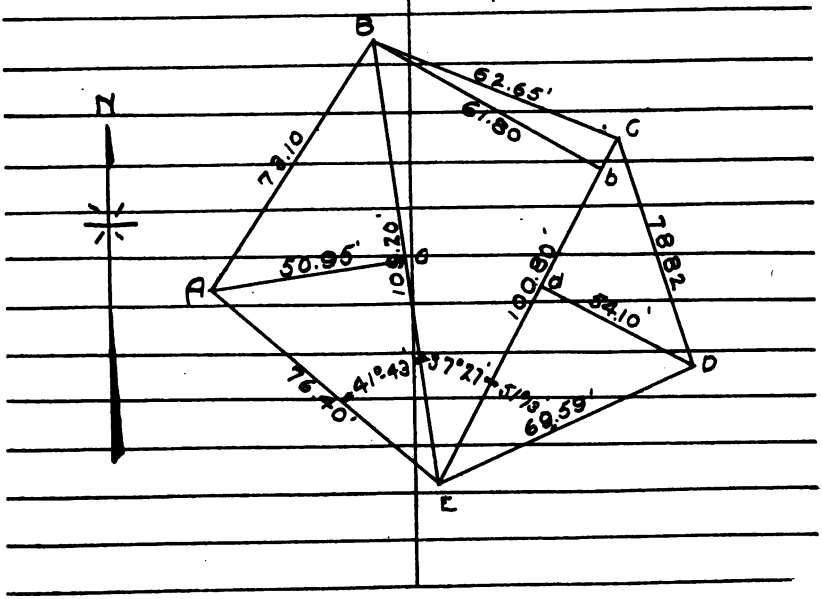
WITH-STEEL-TAPE.

March 24, '12. (3 HRS) Clear And Warm.

Used 100' steel tape, chaining pins, plumb pin, and range poles. Locker # 26.

Measured angles at vertex E by "Chord Method" and by "Tangent Method" and used mean of mean of results. Sides and diagonals were measured carefully. The altitudes were erected by estimating position of foot and laying off exact right angles.

The data is sufficient to compute the area by the "three side" and "altitude" methods.



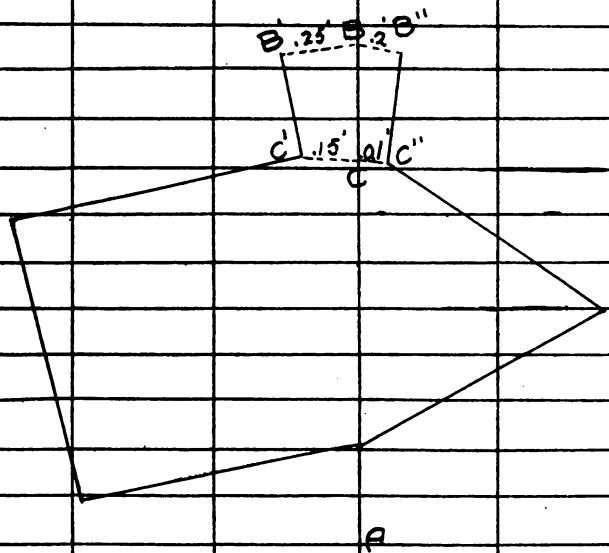
PROLONGATION OF A LINE THRU.

March 24, '12 (2 HRS) WARM AND CLOUDY.

Used 100' steel tape, chaining pins, and range poles Locker #25.

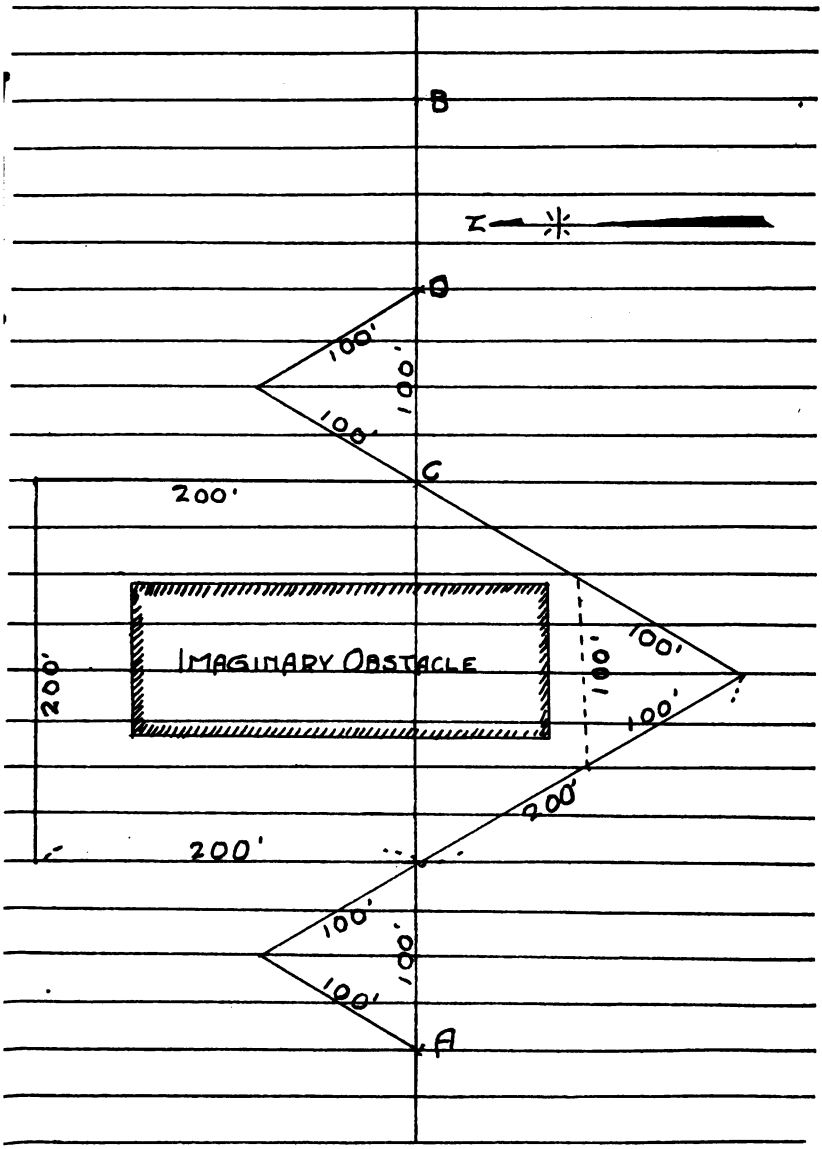
Set three points A, C, and B, in same straight line

Starting from A, measured 100' in line A-B, from this point constructed a square and an equilateral triangle of 200' sides, thus locating points C' and C'' Then prolonged line to points B' & B'' Measuring in each case the error of alignment



T. BROWN
R. SMITH } SURVEYORS

-OBSTACLE-WITH-TAPE.



MEASURMENT-OF-AN-OB-

Given two hubs A and B an unknown distance apart, on smooth ground

Assumed an obstruction to line, as shown in sketch.

Selected point C visible from A and B, chained CA and CB, observing to nearest 0.01 ft and bisected CA at D, CB at E. Chained DE and calculated AB by doubling DE. $200.61 \times 2 = 401.22$

Ran random line from A clearing obstruction. Erected perpendicular to random line from B. Measured BF and AF and calculate b AB = $\sqrt{396.9^2 + 67.25^2}$

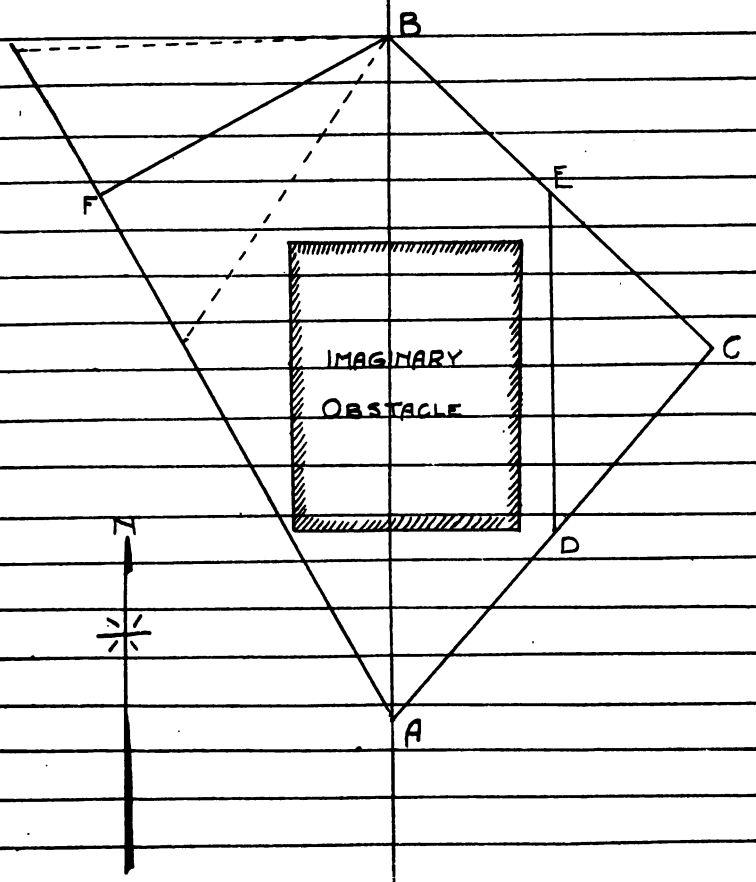
As a check on results the actual distance AB was chained.

METHOD	Observed Dist
By Similar Triangles	401.22
By Random Line	401.15
By Direct Meas.	401.19

STRUCTED-DISTANCE-WITH-TAPE

March 26, '12 (2 Hrs) Cold and Cloudy

Used 100' steel tape, chaining pins and range poles.



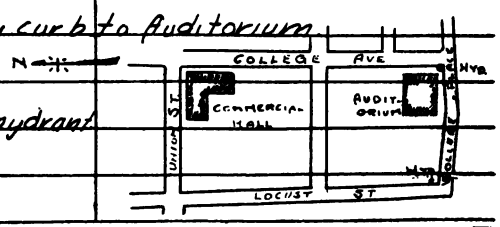
DIFFERENTIAL-LEVELING

STA.	B.S.	H.I.	F.S	ELEV.	SIGHTS
B.M.				778.606	
π (1)	1.64	780.24	4.33		33
⊙ (1)	3.99			775.92	25
π (2)		779.90	3.84		53
⊙ (2)	1.57			776.06	36
π (3)		777.63	6.70		51
⊙ 3	4.03			770.43	
π (4)		774.96	7.10		36
⊙ (4)	2.13			767.86	45
π (5)		769.99	1.34		
⊙ (5)	6.04			768.65	35
π (6)		774.69	2.04		
⊙ (6)	5.89			772.65	70
π (7)		778.54	4.73		33
⊙ (7)	6.50			773.81	30
π (8)		780.31	5.52		48
⊙ (8)	5.66			774.79	36
π (9)		780.45	4.97		36
⊙ (9)	6.18			775.48	
π (10)		781.66	2.90		33
B.M.	+43.63			778.76	
	-43.47			778.61	
	+16	Check		+.15	

J. SMITH - LEVEL
T. BROWN - ROD

WITH-HAND-LEVEL.

April 7, '12 (2 hrs)	Clear and Cool Used LEVEL #74
North bolt of Auditorium hydrant S.L.B.M.	
Corner of retaining curb, S.W. corner Auditorium	
Top of hydrant, cor College Place and Locust St	
Corner of Sidewalk, cor Locust and Freeman Sts	
S. corner of first step, #453 Locust St	
W. corner of first step, #504 Union St.	
Catch basin top, cor Union St & College Ave	
S. edge of driveway curb to Commercial Hall	
Edge of curb next to telephone pole front #84 College	
S. cor of driveway curb to Auditorium	
N. bolt of Auditorium hydrant	



DIFFERENTIAL LEVELING

STATION	B. S.	H. I	F. S	ELEVATION	SIGHTS	
B.M.	1.005	779.611		778.606	56	70
○ 1	5.320	776.721	8.210	771.401	58	66
○ 2	3.125	777.872	1.974	774.747	68	84
○ 3	1.302	776.891	2.283	775.589	72	75
○ 4	6.283	777.313	5.861	771.030	40	44
○ 6	4.261	779.842	1.732	775.581	63	80
○ 6 B.M.	1.451	780.047	1.246	778.596	90	89
○ 7			4.447	775.569		
	+22.747		-25.784	778.606		
			+22.747	775.569		
			-3.037	-3.037		
			Check			

Permissible error of closure = .007 $\sqrt{L}$

" " " " = .036'

Actual error of closure = .010'

T. SMITH, LEVELMAN
J. JONES, RODMAN.

WITH-ENGINEERS-LEVEL.

March 24, '12. (2 Hrs) Fair and Cool.

North bolt of Auditorium hydrant.

H rivet of manhole cover cor Greenwich St & College Place

H. bolt of hydrant in alley opposite Lambke Hall

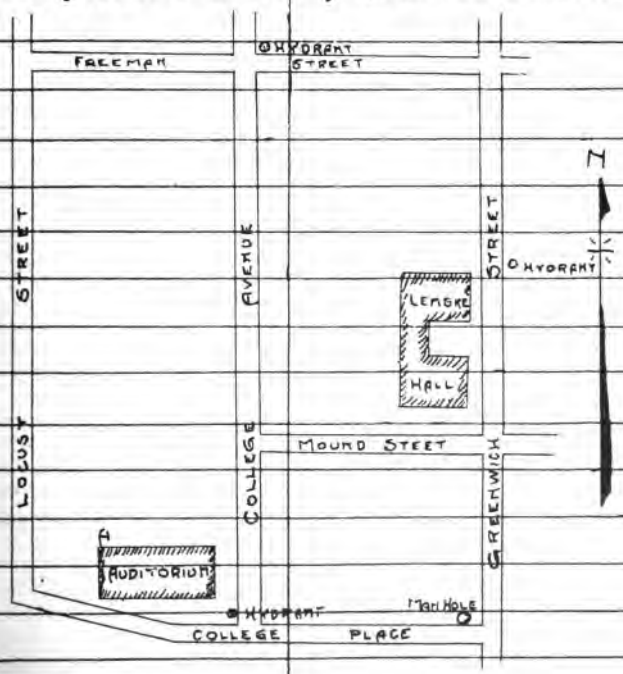
Ho bolt of hydrant cor College Ave & Freeman St

H.E. cor of step above sidewalk #460 Locust St

H bolt of hydrant cor College Place & Locust St

H bolt of Auditorium hydrant

H bolt of hydrant cor College Ave & Freeman St.

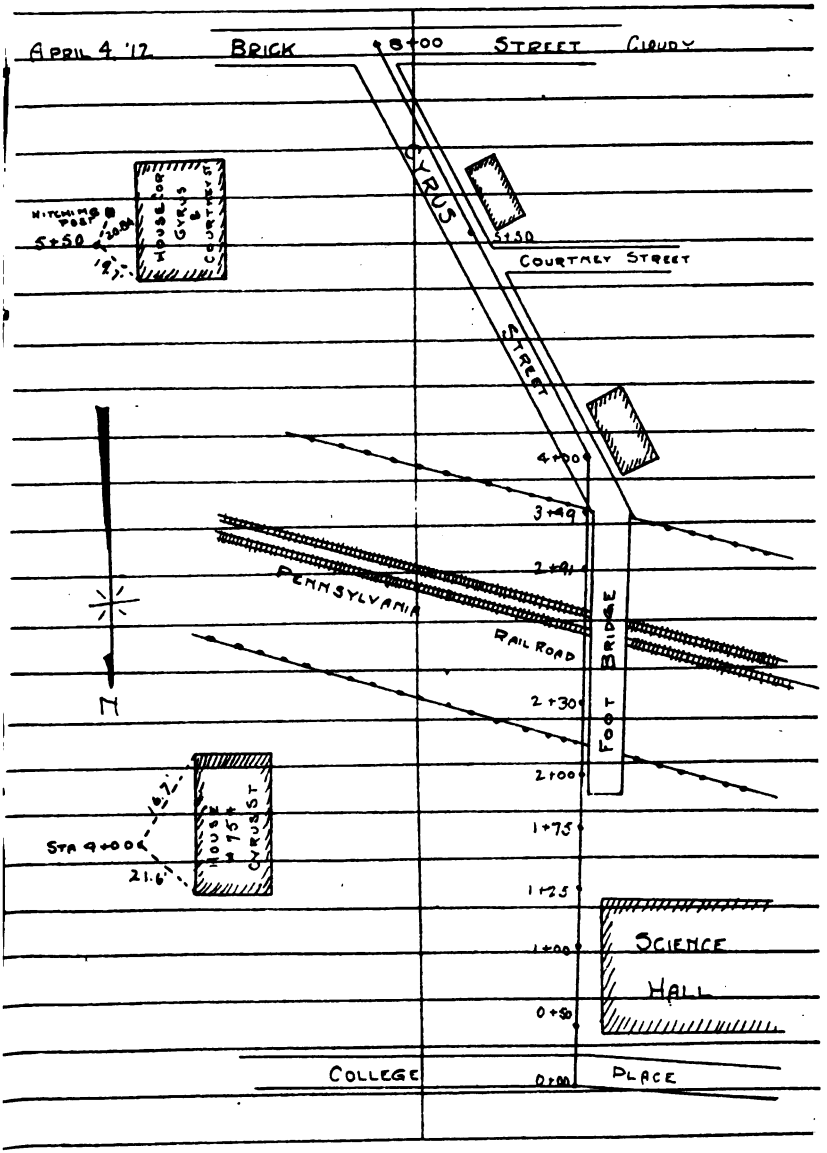


SURVEY-OF-DRAIN-FROM-COLLEGE

STATION	DESCRIPTION				
8+00	Center of Brick St				
7+00	19' from tel pole #3, 11' # 1225.				
6+50	In gutter opposite shed on Cyrus St				
6+00					
5+50	19.7' from N E cor of house cor Cyrus & Courtney				
	Sts. and 20.84 from N W cor hitching post				
5+00					
4+50					
4+00	In gutter on Cyrus St.				
3+49	21.6' from N E cor and 16.7' from S E cor # 7.54				
2+91	Midway on southern bankment of Penn R.R				
2+51	On blazed tie of north track of R.R				
2+30	Top of N embankment of RR				
2+00	5' from blazed tree near north fence of R.R				
1+75					
1+50					
1+25	15' from blazed tree				
1+00	On edge of sidehill				
0+50	37.3' from N.E cor 19.9' from S.E cor Science Hall				
0+00	Point or cut in north curb of College Place				
	at bend in curb line				

J JONES, NOTES.
T BROWN, H CHAIN.
R. SMITH R CHAIN

PLACE-TO-BRICK-STREET.



LEVEL-NOTES-FOR-DRAIN

STATION	B.S.	H.I.	F.S.	SURFACE ELEV	ELEV. GRADE
BM.	4.480	783.086		778.606	
0+00			7.7	775.3	771.3
0+50			6.3	776.7	768.3
1+00	1.095	776.295	7.8	775.2	765.3
1+25			6.45	769.8	762.3
1+50	2.747	767.377	11.66	764.63	759.3
1+75			3.66	763.7	756.3
2+00			12.175	755.202	753.3
2+30	1.030	755.542	12.865	754.512	750.3
2+44			7.3	748.2	747.3
2+62			5.4	750.1	744.3
2+81.			7.9	747.6	743.8
2+92			3.2	752.3	743.5
3+49	1.69	754.18	3.05	752.49	742.8
4+00			3.0	751.1	742.3
4+50			.8	750.3	741.8
5+00			9.9	749.2	741.3
5+50			4.9	749.2	740.8
6+00			4.9	749.2	740.3
6+50			9.8	749.3	739.8
7+00			6.1	748.0	739.3
8+00			6.4	747.7	738.8

COLLEGE-PLACE-TO-BRICK-ST.

CUT		
	April 5, '12 (2 hrs) Fair and Warm.	
	N. bolt Auditorium hydrant	
4.0	Gutter at bend in N. curb line of College Place	
8.4	Hub	
9.9	Hub at top of slope	
7.5	"	
5.3	Hub on side hill	
7.4	"	
1.9	"	
4.2	Hub on top of N. embankment of RR	
0.9	Drain Ditch north side of RR tracks	
5.3	Center between double tracks	
3.8	Drain ditch south of tracks	
9.0		
9.7	Hub on W. curb line Cyrus St.	
8.8		
9.5		
7.9	Hub near Courtney St. on Cyrus St.	
8.2		
9.0		
8.2		
8.4		
7.2	Hub center of Brick St	

CROSS-SECTION-LEVELING

STATION	ELEVATION OF SURFACE	ELEVATION OF GRADE	LEFT	CENTER	RIGHT
0+00	100.0	105.0	-3.7 / 19.3	+5.0	+4.1 / 9.6
1+00	102.5	105.5	-1.4 / 14.6	+3.0	+2.3 / 9.0
2+00	103.2	106.0	+2.6 / 8.1	+2.8	+2.1 / 9.1
3+00	101.3	106.5	+4.0 / 9.0	+4.8	+3.5 / 19.8
4+00	97.7	107.0	-5.2 / 29.8	+9.3	-2.2 / 25.3
5+00	9.86	107.5	+2.0 / 29.0	+9.1	-1.3 / 23.9
6+00	103.1	108.0	+3.4 / 10.5	+4.9	-6.7 / 24.5
7+00	106.4	108.5	-1.2 / 13.8	+2.1	+5.2 / 17.6
8+00	112.8	109.0	-1.7 / 9.2	+3.8	+2.1 / 10.1
9+00	116.7	109.5	+4.2 / 21.2	-7.2	-1.8 / 15.2
10+00	122.3	110.0	+7.1 / 29.1	-12.3	-.5 / 21.5
11+00	128.3	110.5	+5.3 / 32.3	-17.8	-2.6 / 29.4
12+00	132.2	111.0	-0.5 / 30.5	-21.2	-3.3 / 27.3

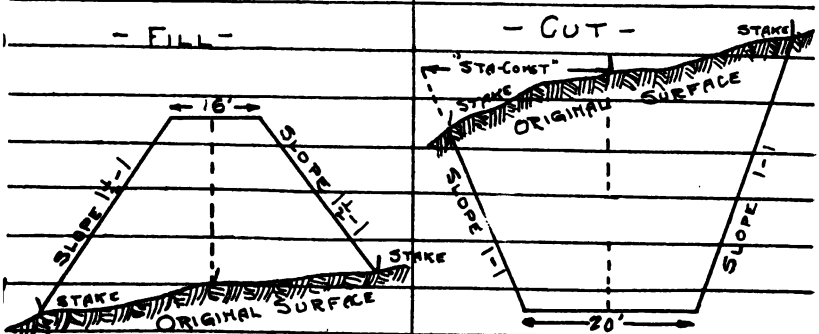
0.5%

T. BROWN, LEVEL
T. SMITH, CHAIN
J. JONES, ROD

FOR-SLOPE-STAKES

April 6, '12. (2 HRS) Fair and Warm.

Given a grade of -.5% and surface elevation, from which the cuts and fills at center are computed. The "station constant" or distance to stake, if section were horizontal, is then computed. A distance to the real stake is estimated and the point located on ground. The diffence between this point and center is found by taking rod readings on each. With the aid of this difference the distance to stake computed by multiplying the difference in elevation by the slope and adding or subtracting it to the "station constant." If the computed distance does not check with assumed, a new distance is estimated and same operation is repeated.



STAKING-OUT-A-BORROW-

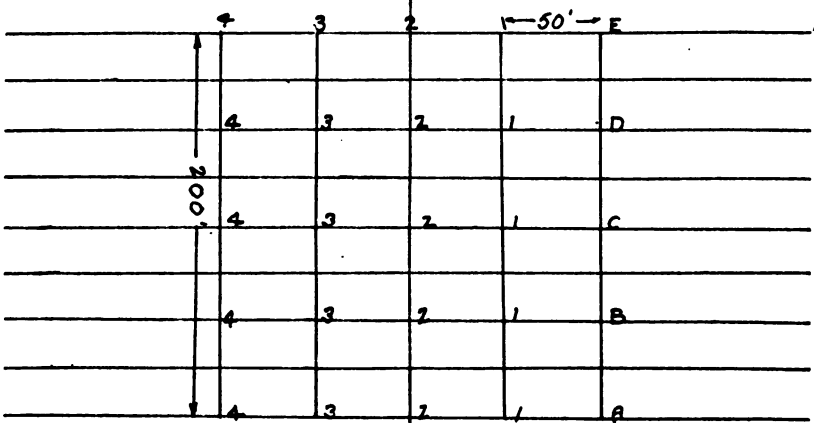
STATION	H.I	F.S.	ELEVATION	CUT	
A	111.335	11.335	100.0	.00	
B		9.90	101.44	1.44	
C		7.89	103.47	3.47	
D		5.68	105.66	5.66	
E		2.86	108.48	8.48	
A-1		9.91	101.43	1.43	
B-1		8.64	102.70	2.70	
C-1		6.65	104.69	4.69	
D-1		4.60	106.74	6.74	
E-1		2.57	108.76	8.76	
A-2		8.30	103.04	3.04	
B-2		7.11	104.23	4.23	
C-2		5.69	105.65	5.65	
D-2		4.01	107.33	7.33	
E-2		1.14	110.20	10.2	
A-3		6.51	104.76	4.76	
B-3		5.86	105.48	5.48	
C-3		4.99	106.35	6.35	
D-3		2.83	108.51	8.51	
E-3		2.87	112.41	12.41	
A-4		4.51	106.83	6.83	
B-4		4.71	106.63	6.63	
C-4	115.275	3.81	107.53	7.53	
D-4		5.54	109.74	9.74	
E-4		.69	114.59	14.59	

PIT FOR ESTIMATE OF QUANTITIES.

April 9, '12 (2 Hrs) Cool and clear.

Used Dumpy Level, M.Y. Rod, Steel Tape, and steel pins Locker #5.

Staked out an area 200' feet square, which was divided into unit areas 50 feet square. Assumed elevation of lowest point as 100', from which the elevations of all corners of unit areas were found in respect to a level grade thru this point. From the cuts thus obtained the yardage of total pit was computed.



V (in cu. yds) $= \frac{A(\Sigma h_1 + 2\Sigma h_2 + 3\Sigma h_3 + 4\Sigma h_4)}{4 \times 27}$

A = Area of unit rectangle, Σ = sum of, h = corner height, subscripts indicate the number of times a corner height is used. $V =$ 9,262.7 cu yds

SURVEY-AND-LEVELS-FOR

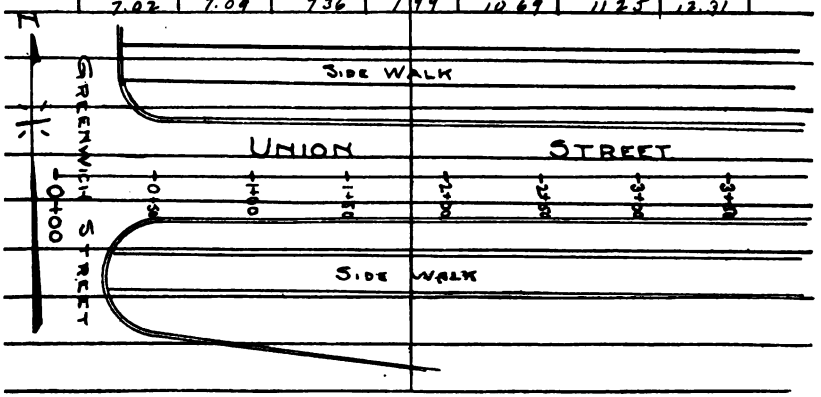
STATION	B.S	H.I	F.S	ELEVATION	
B.M	10.48	789.288		778.808	
0+00			9.69	779.59	
0+50			7.985	781.30	
1+00	10.88	796.448	3.72	785.57	
1+50			7.89	788.56	
2+00			5.30	791.15	
2+50	6.885	800.353	2.98	793.47	
3+00	11.585	806.838	5.10	795.25	
3+50			9.48	797.36	
4+00			5.92	801.92	
4+50	5.715	810.778	3.64	803.20	
5+00			1.78	809.00	
5+50			4.99	805.78	
6+00			7.25	803.53	
6+50			7.99	802.79	

T. BROWN, LEVEL
R. SMITH, ROD.
J. JONES, CHAIN

GRADING -A- STREET.

April 10, 11, '12 (4 Hrs) Warmand Clear

L. PROP	L. S. WLK	L. GUTTER	CENTER	R. GUTTER	R. S. WLK	R. PROP
			779.59 / 9.49			
781.59 / 7.69	781.44 / 7.85	780.74 / 8.55	781.303 / 7.98	782.20 / 7.09	782.69 / 6.60	781.67 / 7.62
784.258 / 5.03	783.97 / 5.32	784.49 / 4.80	785.57 / 3.72	785.79 / 3.50	787.09 / 2.2	788.28 / 1.0
787.09 / 9.35	786.38 / 10.07	787.61 / 8.84	787.56 / 7.89	789.13 / 7.32	791.09 / 5.37	791.35 / 5.10
789.81 / 6.64	789.07 / 7.38	789.94 / 6.51	791.15 / 5.30	793.17 / 3.28	793.65 / 2.30	793.69 / 2.75
792.72 / 3.73	791.65 / 4.80	792.45 / 4.00	793.47 / 2.98	794.38 / 2.07	794.97 / 1.48	794.61 / 1.78
795.27 / 5.88	795.02 / 5.33	794.39 / 5.96	795.25 / 5.10	796.32 / 4.03	796.56 / 3.79	796.38 / 4.07
797.04 / 9.79	794.98 / 11.86	796.17 / 10.66	797.36 / 9.48	797.94 / 8.9	798.81 / 8.03	798.79 / 8.05
799.99 / 6.84	799.87 / 6.97	799.87 / 6.97	800.92 / 5.92	801.18 / 5.66	801.31 / 5.63	801.32 / 5.52
802.29 / 4.55	801.01 / 3.83	803.28 / 3.56	803.20 / 3.64	804.01 / 2.83	804.30 / 2.54	804.29 / 2.35
804.29 / 2.55	805.32 / 1.52	806.76 / 1.08	805.06 / 1.78	806.63 / 26	806.54 / 30	806.64 / 20
805.08 / 5.70	806.38 / 4.40	806.41 / 4.37	805.78 / 4.99	806.97 / 3.81	806.84 / 3.94	806.38 / 4.40
805.33 / 5.45	804.82 / 5.96	805.81 / 5.98	803.63 / 7.75	802.30 / 8.48	801.78 / 8.99	801.93 / 9.85
803.16 / 7.02	803.69 / 7.09	803.42 / 7.36	802.79 / 7.99	800.08 / 10.69	799.53 / 11.25	798.97 / 12.31



ADJUSTMENT-OF-A-

The principal lines in the adjustment of the Wye Level are:

(1) The "line of sight" from the intersection of the cross hairs to the optical center of the object glass.

(2) The "line of collimation" with which the line of sight should be made to coincide

(3) The axis "of the collars or rings", a line joining the centers of the rings.

(4) The "axis of the bubble"

(5) The "line of the bottom of the wyes"

(6) The "axis of the level bar"

I

— ADJUSTMENT OF THE CROSS HAIRS —

OBJECT.- To make line of sight coincide with axis of collars

TEST. - Sight on an some well defined point and after loosening clips revolve telescope halfway in wyes and intersection of cross hairs should remain on point

CORRECTION: Move cross hairs until cross hairs remain on fixed point thru entire revolution.

II

— ADJUSTMENT OF BUBBLE TUBE —

OBJECT:- To make axis of spirit bubble in same vertical with line of sight.

WYE-LEVEL

(2) To make axis of the bubble parallel to line of sight

TEST:- Level up bubble and revolve telescope thru a few degrees in wyes. If bubble does not remain in center, it should be adjusted.

CORRECTION:- Bring bubble all the way back to the center by moving lateral adjusting capstan screws.

TEST:- Level up bubble and remove telescope from wyes and replace with position reversed. The bubble should remain in center.

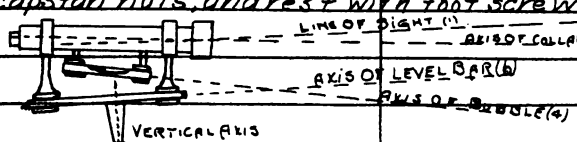
CORRECTION:- Correct half apparent error with altitude capstan screw and bring rest of the way back by means of foot screws.

— ADJUSTMENT OF THE WYES —

OBJECT.- To Make axis of level bar parallel to line of sight

Test.- Level up over a pair of foot screws and revolve thru 180° and the bubble should remain in center of graduations.

CORRECTION: Correct half apparent error with large capstan nuts, and rest with foot screws.



ADJUSTMENT OF A

The Principal lines to be adjusted are:-

(1) THE "line o sight"

(2) The "axis of spirit bubble"

(3) "Axis of level bar"

I

- ADJUSTMENT OF CROSS HAIRS AND BUBBLE TUBE -

OBJECT: To make line of sight and axis of spirit bubble parallel.

TEST AND ADJUSTMENT:- BY "TWO PEG METHOD".

II

- ADJUSTMENT OF STANDARDS -

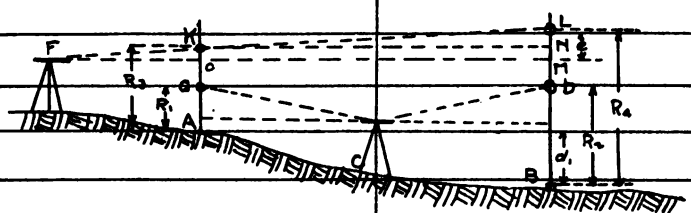
OBJECT:- To make line of sight and axis of level bar parallel.

TEST:- Level up bubble over a pair of foot screws and reverse, the bubble should remain in center of graduations.

ADJUSTMENT: correct half of apparent error by means of screws on underside of level bar, and rest with foot screws.

DUMPY-LEVEL.

THE "PEG ADJUSTMENT"



TEST:- Drive two stakes 300' to 400' = AB. Set instrument up over mid point (C) and observe rods on (A) and (B). The diff. in readings will give (d_1) the true diff. in elev. Set up again a known distance behind (A) and observe two more rod readings. This difference in readings (d_2) should equal (d_1). If d_2 is greater the line of sight inclines upward, if less downward.

Adjustment: Compute error of line F-L in dist. FM. From similar triangles $e = \frac{FM}{CM}(d_1 - d_2)$. The target is then brought down to its correct position M by adding or subtracting (e) from reading (L). The cross hairs may be moved to this reading, or the line of sight brought down by foot screws and axis of bubble moved

ANGLES OF A TRIANGLE

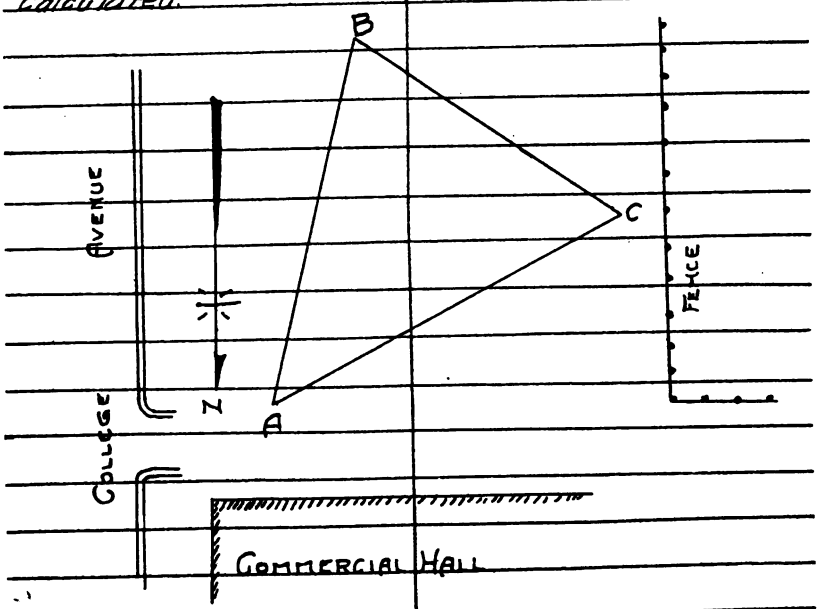
Station	Line	Observed Needle	Angle
C	C A	N 71° 45' E	
C	C B	S 64° 55' E	44° 0'
A	A B	S 3° 55' E	
A	A C	S 71° 30' E	75° 25'
B	B A	N 4° 25' W	
B	B C	N 65° 5' W	60° 30'
			179° 55'

WITH-COMPASS.

April 4, '12. Clear and Warm

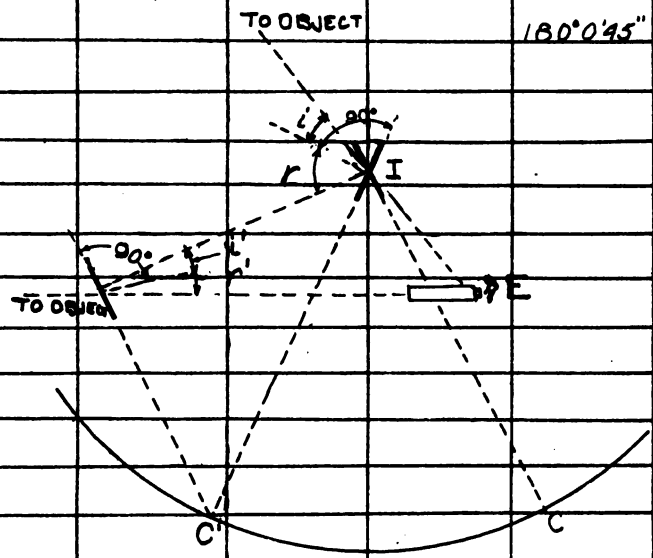
Used Surveyor's Compass and Tripod and range poles. Locker # 26.

Set compass over tack by means of plumb bob. Leveled up by means of attached spirit bubbles. Lowered needle onto pivot and sighted point and read bearing to nearest 5 minutes. Raised needle from pivot and repeated. Observed bearing of other line in like manner. From bearings thus obtained the included angle was calculated.



ANGLES-OF-A-TRIANGLE-

STATION	SEXTANT ANGLE	INDEX ERROR	CORRECTED ANGLE	MEAN ANGLE
A	56°14'	1°12'	57°26'	
A	56°13'30"	"	56°25'30"	56°25'45"
B	33°6'30"	"	34°18'30"	
B	33°6'	"	34°18'	34°18'15"
C	88°3'30"	"	89°15'30"	
C	88°5'30"	"	89°17'30"	89°16'45"
				180°0'45"



$i = r'$ and $r' = i'$, $E = (i+r) - (i'+r') = 2(r-r')$

$C' = (90° - r') - (90° - r) = (r - r')$ $\therefore E = 2C'$

BUT $C' = CIC$ BY GEOM.

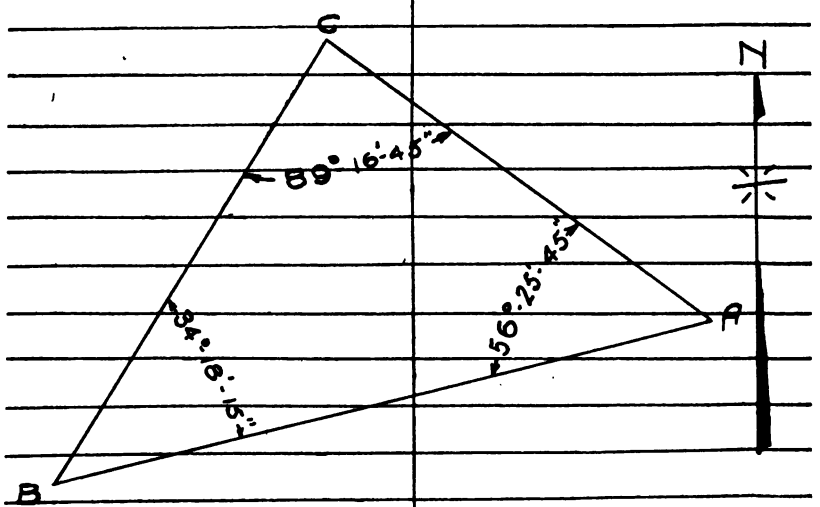
WITH-A-SEXTANT.

April 5, 12. (2 Hrs) Clear and Warm

Used Sextant and range poles. Locker #20

First determined index error of instrument by sighting on range pole at a great distance, causing the indirect image to coincide with the real and taking the reading on the limb

Held sextant over point A, sighted at pole on B and caused it to become coincident with that from C. Repeated same angle with sextant inverted. Repeated operation on stations B and C.



ANGLES-OF-A-TRIANGLE-

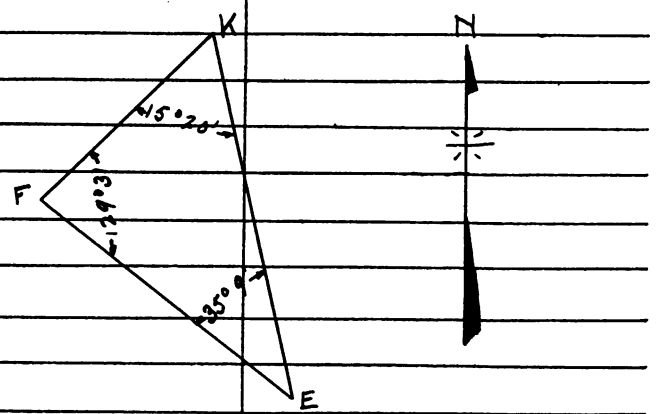
STATION	VALUE OF ANGLE				
F	129°31'	129°31'	129°31		
E	35°9'	35°9'	35°9'		
K	15°21'	15°20'	15°20'30"		
			180°0'30"		
	Error of Closure 30"				
	Allowable Error = 1'				

WITH-ENGINEER'S-TRANSIT.

April 14, '12 (2 HRS) Cool and Party.

Used Gurley Transit #6 and Range Poles.

Instrument was setup over station F, with index reading zero sighted point E and loosened upper clamp and sighted point K. Read position of index on limb and added to it reading of vernier. Repeated angle except the angle was laid off to the left. Thence moved transit to other two stations and repeated same operation. Each angle was read to nearest minute, and a mean taken.



U. JONES, TRANSIT.
T. SMITH, FLAG.

PROLONGATION-OF-A-LINE

Located stations (A) and (K), set transit over point (A) and sighted to point (K), locating point (B) in line A-K, and removed flag at (K)

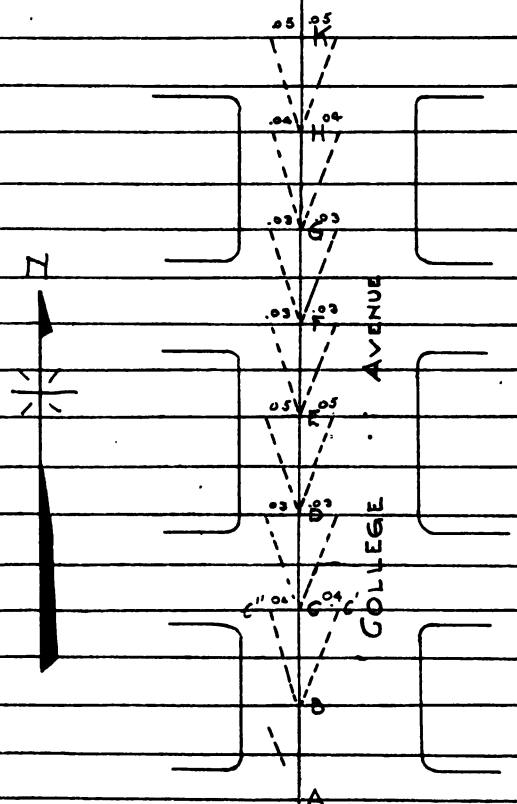
Removed transit to (B), backsighted to A and plunged telescope, locating (C'). Loosened lower motion, turned in azimuth, backsighting to (A), plunged telescope and located point (C"). The correct point (C) was locate by taking mean of positions of C' and C". The transit was removed other stations and operation repeated. When the final point K was reached the error of alignment was measured, which was .01'

Allowable error is $.01\sqrt{\text{No of Sights}}$ when 300' sights are used.

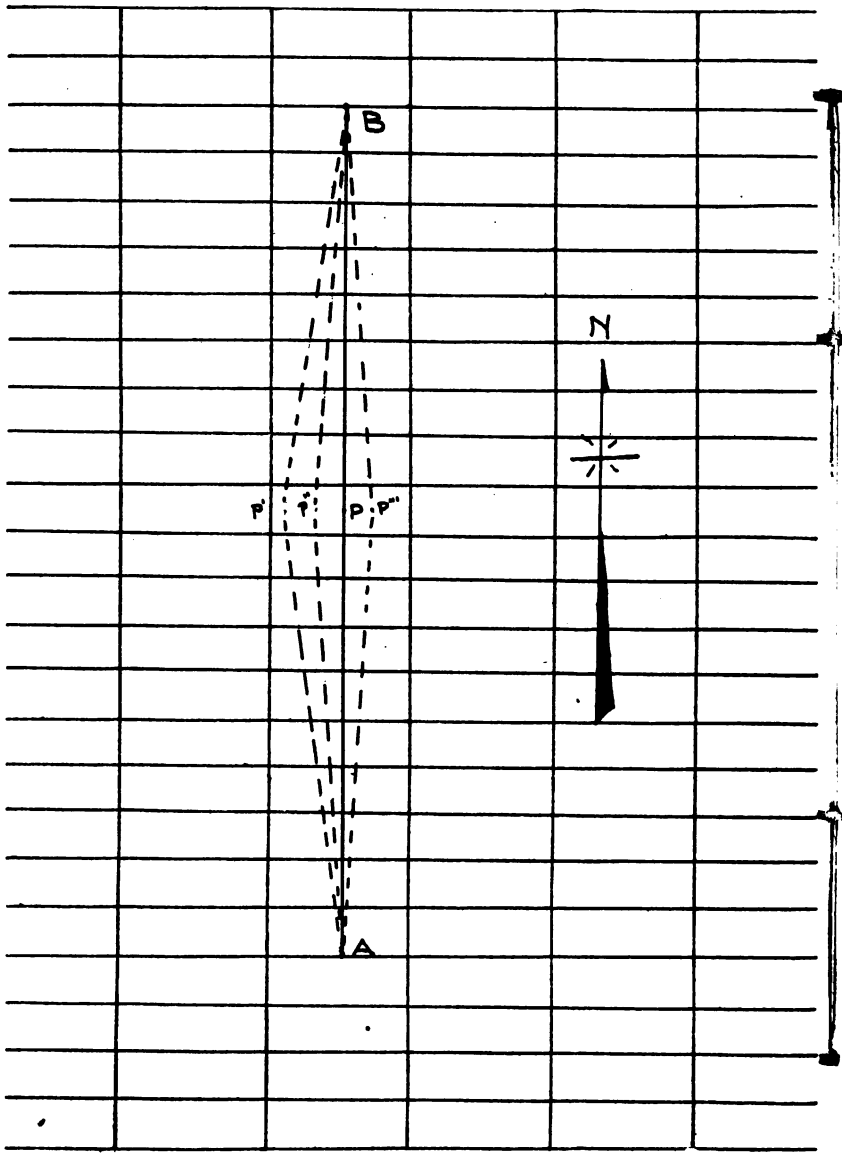
WITH-ENGINEER'S-TRANSIT.

April 16, '12. (1½ Hrs.) Fair and Warm.

Used Gurley Transit #7.



BALANCING - IN - A -



T. BROWN, TRANSIT
J. JONES, FLAG.
R. SMITH, FLAG

TRANSIT.

April 17. '13. (2 Hrs) Fair and Cool.

Used Transit from Locker #8.

Located range poles at points (A) and (B) which are not visible from each other. It is desired to locate point (P) in line AB, which is visible from A and B. The position of P was estimated and checked by backsighting to one of the points and plunging, to see if line of sight strikes other point. This operation is repeated and if found exactly by using shifting head. The position is finally checked by double sighting. If it does not a new point is found and real point (P) is found by taking mean of points by each method.

CENTER-OF-A-TRIANGLE

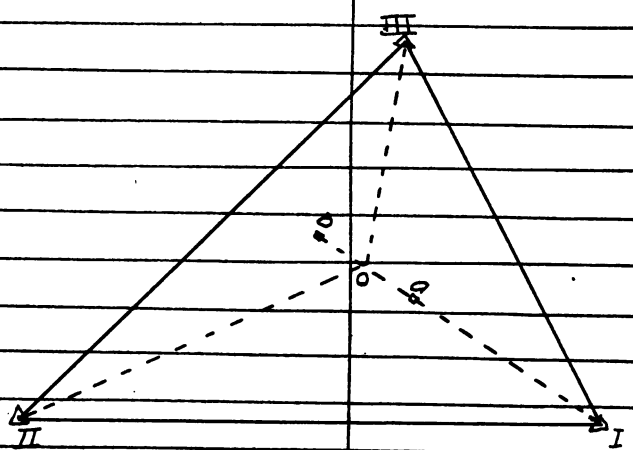
STATION	WHOLE ANGLE	L. HALF ANGLE	R HALF ANGLE	ERROR ANGLE	DIST.
1	73°52'	36°56'	36°56'		
2	52°8'	26°4'	26°4'		
3	54°0'	27°0'	27°0'	0	0
	180°0'				
		Allowable Error		1.0'	
		Check			
STATION	ANGLES				
0	1-0-2	116°56'			
	2-0-3	126°56'			
	3-0-1	116°8'			
		360°0'			
	Allowable Error 1.0'				

WITH-A-TRANSIT.

April 18, '12 (2 Hrs) Fair and Warm

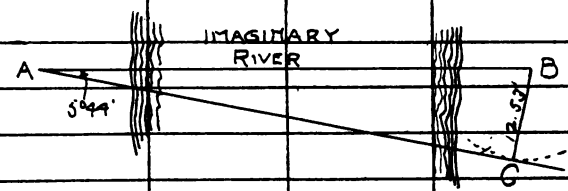
Used K&E. Transit #14

Set transit over △ I, measured angle 3-1-2. Layed off half the angle and located points (a) and (b) on line near center of △, but on opposite sides. Repeated operation at sta (2) and located (O) in line a-b. Set up on sta. (3) and checked point O. As a final check set up over (O) and measured angles at center.

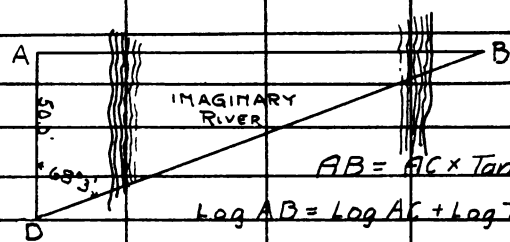


TRIANGULATION-

STATION	ANGLE	LINE			
A	5°44'		CHAINED DIST = 125.03		
		BC = 12.53	AB = 12.53×10 = 125.3'		



STATION	ANGLE	LINE	DIST		
D	68°3'	DA	50.0		



AB = AC × Tan 68°3'

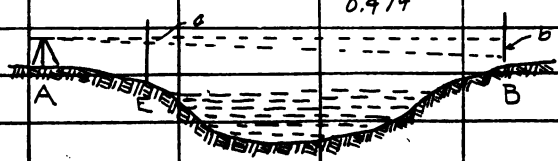
Log AB = Log AC + Log Tan 68°3'

log AC = 1.698970

log Tan 60°3' = .39468 = 2.09365 = 124.97

ROD AT	FIRST READING	SECOND	DIFF.		
E	5.004	4.525	a = 0.470		
B	6.930	0.930	b = 6.00		

a : b = AE : AB AB = $\frac{6.10}{0.479}$ = 12.52



WITH · TRANSIT.

April 20. '12. (2 Hrs) Fair and warm.

Used Dietzgen Transit #13, Rod & Steel Tape.

Found inaccessible distance A-B. First layed off 5°44' and measured ⊥ from B to this line by swinging tape until tangent to line. This method is called "Rule of Tan", for the other side of triangle is equal to this perpendicular multiplied tan.

The second method is simple triangulation. By measuring the angles at the extremities of a known base line.

The third method consists of the solution of similar triangles determined by rods held on each station.

Finally the distance was actually measured with the tape.

PASSING-AN-OBSTACLE

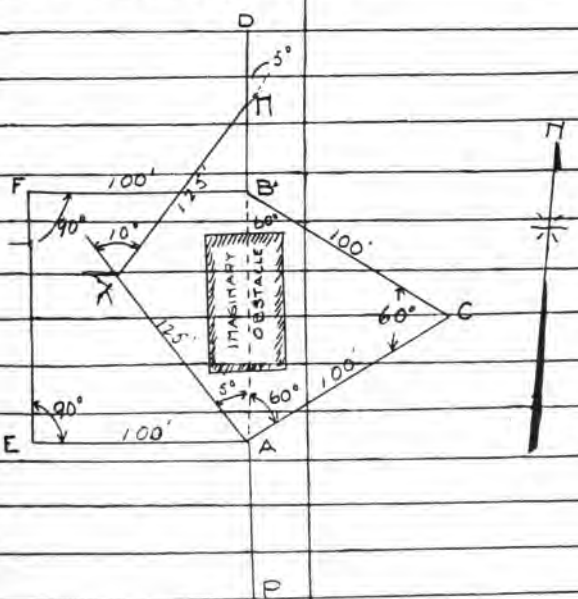
STATION	DISTANCE	ANGLE	VALUE	ERROR OF CLOSURE DIST. FT.	LINE FT.
	"EQUILATERAL TRIANGLE METHOD"				
A	100.0'	B-A-C	60°		
C	100.0'	A-C-B	60°		
B	100.0'	C-B-A	60°		
A-B	100.03'			.03'	0.06L
	"RIGHT ANGLE OFFSET METHOD"				
A	100.0'	AEF	90°0'		
E	100.0'	EFB	90°0'		
F	100.0'	FAE	90°0'		
AB	99.98'	FBD	90°0'	.02'	0.1R
	"DEFLECTION METHOD"				
A	125.0'	DAF	5°0'		
K	125.0'	GFH	10°0'		
M	248.16'	FGD	5°0'		
A-N	248.22			.06'	.04R

WITH-TRANSIT.

April 22 '12 (2 Hrs) Fair and Warm

Used GURLEY TRANSIT #8

Set hubs at P, A and D, and it is desired to pass imaginary obstacle. Set transit over A and prolonged line by "Equilateral Triangle Method," The "Right Angle Method," and the "Deflection Method" The error of alignment through point D was measured, and actual distance between points



CLOSED - TRAVERSE - BY

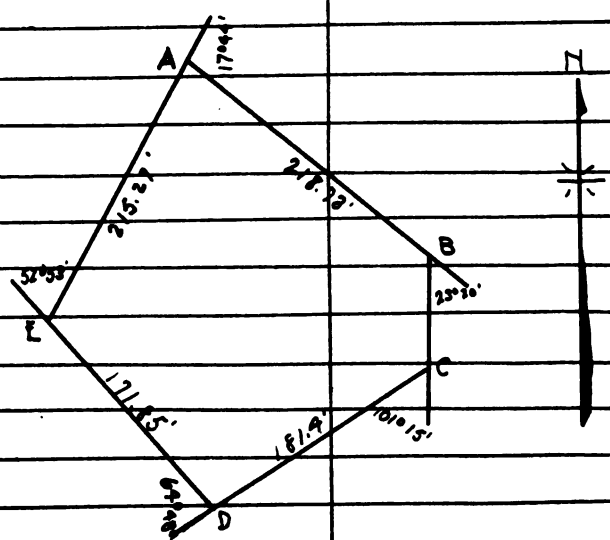
STATION	DISTANCE FT.	DEFLECTION ANGLE	MAGNETIC BEARINGS	CHECK ANGLE	CALCULATED BEARING
A	218.73	117°44'	S 32°E	117°40'	S9°27'E
			S 30°20'W		
B	168.25	23°20'	S 10°E	23°30'	S14°08'W
			S 33°30E		
C	184.10	101°15'	N 89°10'W	100°50'	N69°48'W
			S 10°E		
D	171.85	69°48	N 24°30'W	64°50'	N0°
			N 89°20'W		
E	215.27	52°53'	N 21°W	53°	N52°53'
		360°0'	S 32°W	359°50'	

DEFLECTION-ANGLES.

April 21, '12 (2 Hrs) Warm and Cloudy

Used Mountain Transit #17, steel tape, chaining pins, and flag poles.

Set up transit over each station, backsighted on previous station, noticing magnetic bearing, plunged telescope and sighted to next station, observing the deflection angle, and magnetic bearing, from which the deflection was checked. The sides were carefully measured. The side DE was used as a reference meridian and bearings of all other sides were calculated in respect to it



HEIGHT OF AUDITORIUM

STATION	VERTICAL ANGLE	ROD READING	DISTANCE FEET		
A	17°41'	7.25 = h_1			
B	31°43	4.75 = h_2			
A to B			100.00	= D_1 D_2	

CALCULATION FOR HEIGHT

(1) $D_1 = H_1 \cot M$

(2) $D_2 = H_2 \cot N$

(3) $H = H_1 + h_1 = H_2 + h_2$

(4) $H_1 = H_2 - (h_1 - h_2)$

Now substitute (4) in (1) and subtract (2) from (1) obtaining

(5) $D_1 - D_2 = H_2(\cot M - \cot N) - (h_1 - h_2)\cot M$

(6) $H_2 = \dfrac{D_1 - D_2 + (h_1 - h_2)\cot M}{\cot M - \cot N}$

Substituting

$$H_2 = \frac{100 + (7.25 - 4.75)\cot 17°41'}{\cot 17°41' - \cot 31°43'}$$

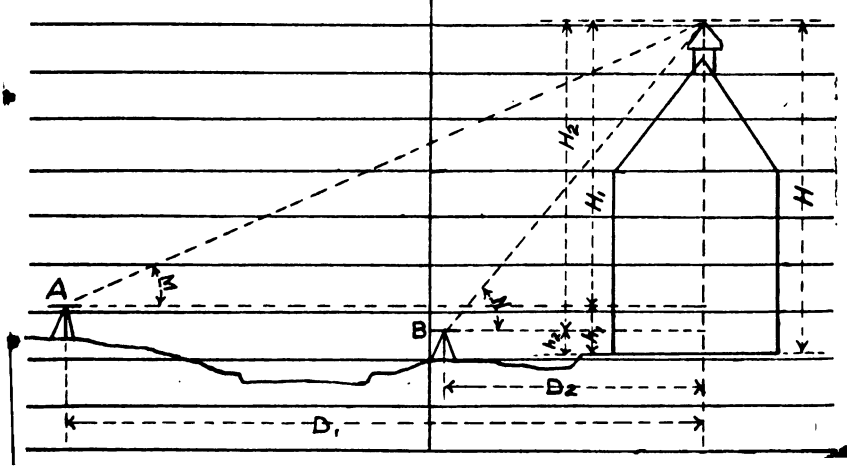
$$= 71.02 \text{ ft.}$$

$$H = H_2 + h_2 = 71.02 + 4.75 = 75.77 \text{ ft.}$$

A. Brown, Transit.
H. Smith, Chain.
B. Jones, Rod.

VENTILATOR

April 17, 1913 (2 Hrs) Cool and Cloudy.
Used Keuffel & Esser Transit, Locker No 6
Set up over A. Leveled telescope by the attached bubble and found index correction for vertical circle. Measured vertical angle M to topmost point of ventilator, corrected for index error and recorded.
Read level rod (with telescope level) on sidewalk close to Auditorium.
Set B in line with A and ventilator and measured A to B
Set up over B and found vert. angle N.
Took rod reading on same point as above.



STAKING OUT A BUILDING

Southeast corner of building to be set 1 ft. from South and East property lines.

Located Hub A in reference to corner as described above at 3' 00 set.

Set up at A and located B and D, measuring the distances carefully.

Set up at B, backsighted at B and located C.

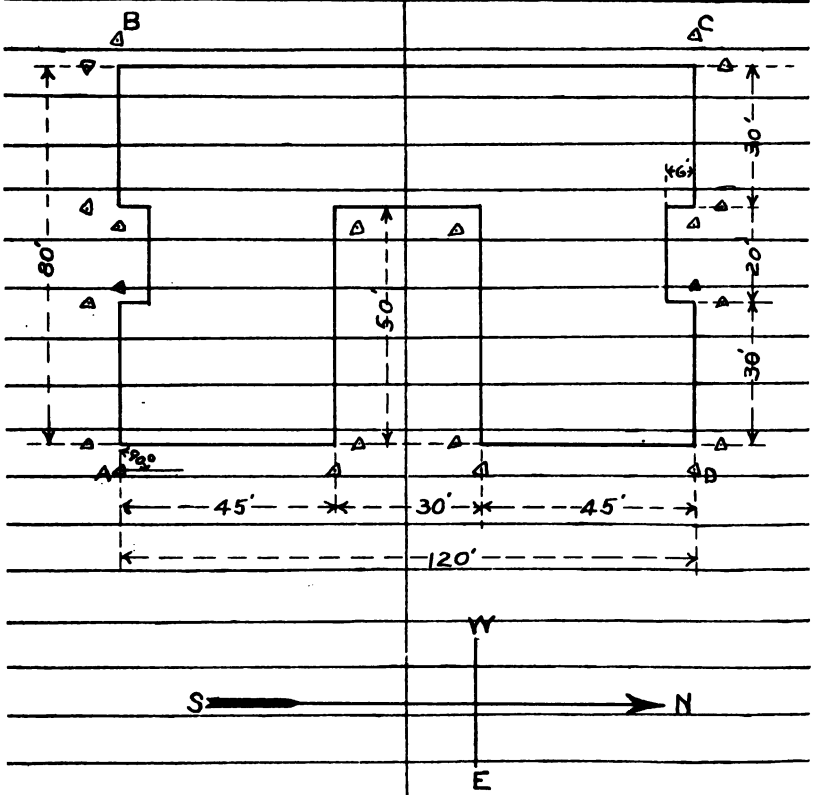
Set up at C and checked location of D. Found line error to be 1/32", and distance error to be 1/16".

Then set the remaining hubs with reference to the rectangle ABCD.

J. Smith, Transit.
F. Jones, Chain.
H. Clark, Chain.

WITH. TRANSIT

April, 18, 1913 (2 Hrs) Warm and Clear
Used Keuffel & Esser Transit, Locker No. 9
Set all Hubs 3 ft from corners on line.



ANGLES OF TRIANGLE

Set up at each corner of triangle and measured angle 5 times with telescope normal and 5 times with telescope inverted. Read both verniers and recor- first and fifth readings.

STATION	BUBBLE	DIRECTION	OBJECT	VERN. A.	VERN. B.	MEAN.
A	DOWN	LEFT	B	00°00'00"	180°00'00"	00°00'00"
			C	50°03'00"	230°00'00"	50°03'00"
				250°12'00"	70°12'00"	250°12'00"
	UP	RIGHT	C	180°00'00"	00°00'00"	00°00'00"
			B	230°03'00"	50°03'00"	50°03'00"
				70°10'00"	250°10'00"	250°10'00"
B	UP	RIGHT	A	0°00'00"	180°00'00"	0°00'00"
			C	69°02'00"	249°02'00"	69°02'00"
				345°16'00"	165°16'00"	345°16'00"
	DOWN	LEFT	C	180°00'00"	0°00'00"	0°00'00"
			A	249°03'00"	69°03'00"	69°03'00"
				165°15'00"	345°15'00"	345°15'00"
C	UP	RIGHT	B	0°00'00"	180°00'00"	0°00'00"
			A	60°54'00"	240°54'00"	60°54'00"
				304°34'00"	124°34'00"	304°34'00"
	DOWN	LEFT	A	180°00'00"	0°00'00"	0°00'00"
			B	240°55'00"	60°55'00"	60°55'00"
				124°35'00"	304°35'00"	304°35'00"

ABC BY REPETITION

April 19, 1913 (2 Hrs) Clear and Cool

M. Smith, Transit.

F. Jones, Notes.

C. Clark, Flag

ANGLE	MEAN ANGLE	REMARKS
		Single Observation
50°02'24"		5 Repetitions
		Single Observation
50°02'00"	50°02'12"	5 Repetitions
		Single Observation
69°03'12"		5 Repetitions
		Single Observation
69°03'00"	69°03'06"	5 Repetitions
		50°02'12"
		69°03'06"
60°54'48"		60°54'54"
		180°00'12"
		(Error not to exceed
		15")
60°55'00"	60°54'54"	

AZIMUTH-TRAVERSE-WITH

STATION INST.	OBJ.	AZIMUTH	DISTANCE	VERTICAL ANGLE	ELEVATION FT.
A					718.0'
	F	0°0'	432	+0°20'	
	B	196°13'	622	-0°40'	(-7.2)
B					710.8
	A	18°13'	624	+0°38'	
	C	227°16'	999	+0°50'	(+7.3)
C					718.1
	B	47°16'	499	-0°50'	
	D	0°03'	758	-1°10'	(-15.4)
D					702.7
	C	180°03'	756	+1°12'	
	E	6°14'	618	+0°56'	(+10.1)
E					712.8
	D	186°14'	618	-0°56'	
	F	89°46'	473	+0°54'	(+7.4)
F					720.2'
	E	269°46'	475	-0°54'	
	A	180°01'	434	-0°20'	-2.5
A					717.7'
	Error 01'				718.
				Error 0.3	

TRANSIT-AND-STADIA.

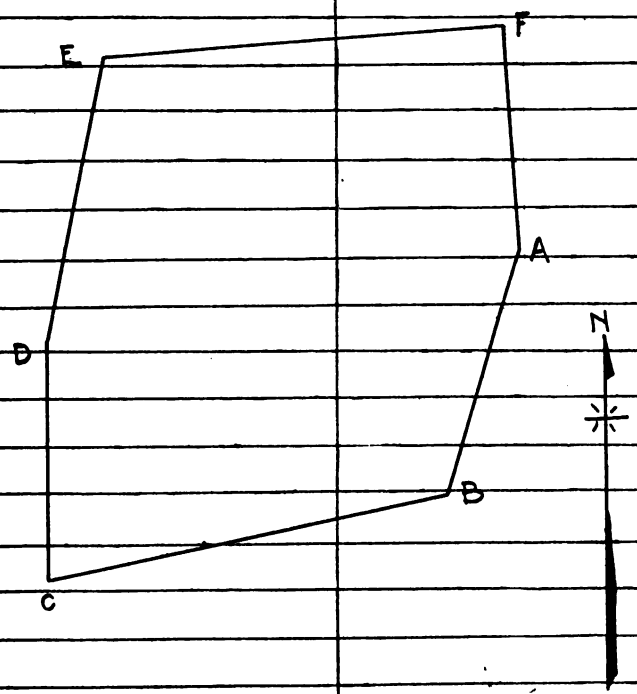
April 22. '12 (2 Hrs) Clear and Warm

Used K.&E. Transit #14, and stadia rod #9

Stadia constants c+f = 1.17' K = 100.0

Sighted at target set at H.I. for vert. angles

Oriented the Transit by Azimuth reversals.



SURVEY OF A

Lot Located Southwest Corner of Locust and Union Sts. Property of M.M. Thompson, #360 Locust St.

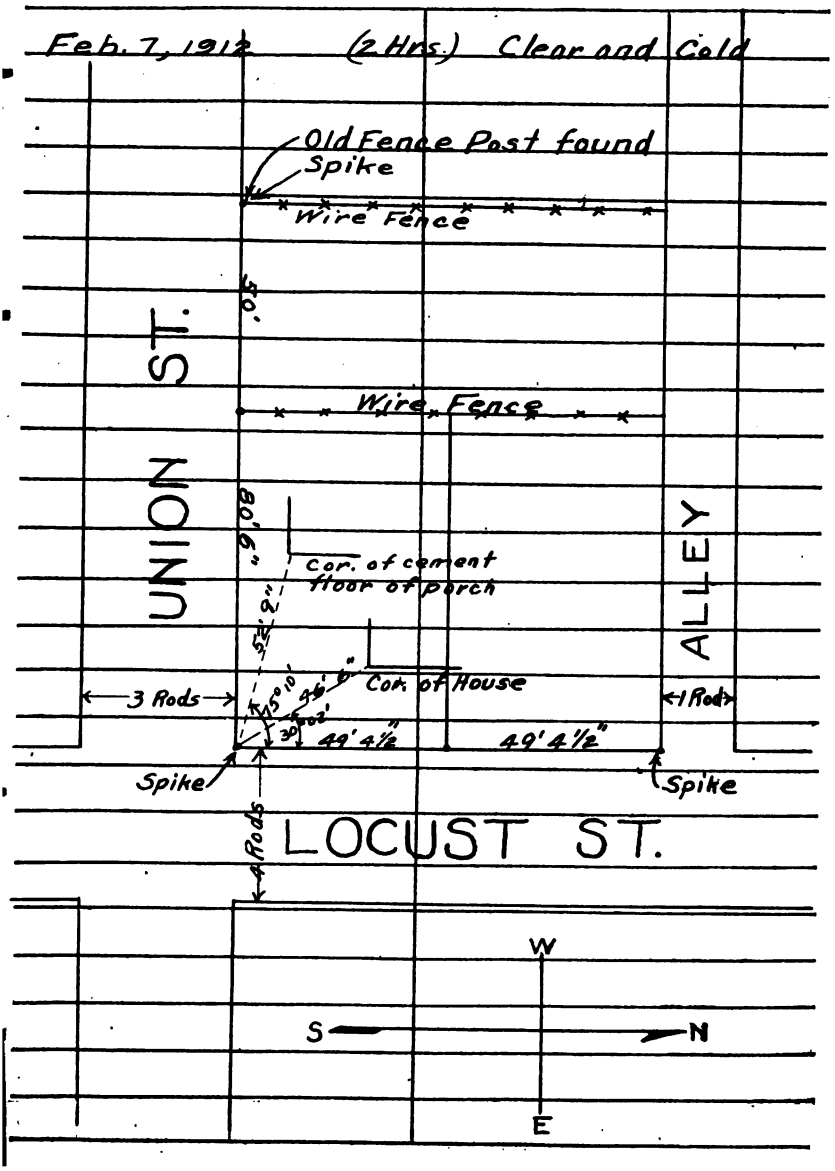
The notes of the survey were taken from notes in the County Recorder's office.

The center lines of Locust and Union Sts. were first established. The transit was set up on the property line of Locust St. some distance north of Union St. and two pins set on line a few feet on either side of where the Union St. property line would intersect the Locust St. property line. Then set up on property line of Union St and the intersection of the property lines established. Then the distances to the lot lines were measured, the transit giving line. The distances and line checked very accurately to the lot corners.

F. Jonens, Transit
M. Smith
C. Clark } Chain.

CITY LOT

34.



LEVELS - FOR - CONTOURS -

STATION	HI = 101.8 F.S.	ELEV.			
A	4.7	97.1	B-7	8.1	93.7
A-1	8.0	93.8	B-8	6.1	95.7
A-2	9.9	91.9	B-9	5.0	96.8
A-3	11.0	90.8	B-10	4.1	97.6
A-4	13.8	88.0	B-11	4.8	97
A-5	11.0	90.8	B-12	5.5	96.3
A-6	9.8	92.0	B-13	6.5	95.3
A-7	8.7	93.1	B-14	7.7	94.1
A-8	9.5	94.3	B-15	8.8	93.0
A-9	6.7	95.1	C-1	4.9	96.9
A-10	6.1	95.7	C-2	7.4	94.4
A-11	6.0	95.8	C-3	9.2	92.6
A-12	6.8	95.0	C-4	10.7	91.1
A-13	7.5	94.3	C-5	13.7	88.1
A-14	8.7	93.1	C-6	11.4	90.4
A-15	9.4	92.4	C-7	9.1	92.7
B-1	4.5	97.3	C-8	7.8	94.0
B-2	7.8	94.0	C-9	5.6	96.2
B-3	9.5	92.3	C-10	3.5	98.3
B-4	10.0	91.8	C-11	3.4	98.4
B-5	13.8	88.0	C-12	3.2	98.6
B-6	11.4	90.4	C-13	5.6	96.2
	9.2	92.6	C-14		

OF- FIELD.

April, 14, '12 (4 HRS) Fair and Warm.

Used Wye Level, 14' N.Y. Rod, Chaining Pins, Steel Tape, Locker #1

Staked out field into unit areas, and elevations were obtained at each corner. From these elevations contours were drawn by interpolation.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
92.4	93.1	94.3	95.0	95.8	95.7	95.1	94.3	93.1	92.0	90.8	88.0	90.8	91.9	93.8	97.1 A
93.0	94.1	95.3	96.3	97	97.6	96.8	95.7	93.7	92.6	90.4	88.0	91.8	92.3	94.0	97.3 B
94.3	96.2	97.8	98.6	98.4	98.8	96.2	94.0	92.7	90.4	88.1	91.1	92.6	94.4	96.9	C
95.1	95.9	97.1	98.0	99.1	99.7	98.6	96.4	94.7	92.8	90.7	88.2	90.9	93	94.8	96.0 D
96.2	96.7	96.3	97.8	98.8	98.9	98.0	96.4	94.2	92.4	91.0	89.0	90.9	92.6	94	95.7 E
94.4	92.8	96.6	96.3	97.0	97.6	96.3	95.2	93.9	92.1	90.6	88.0	90.3	92.4	93.2	94.4 F
93.4	93.6	94.1	95.7	96.1	96.0	94.8	93.9	92.0	91.7	88.9	88.0	90.1	91.6	92.9	93.7 G
93.2	93.4		93.0	93.9	93.8	93.1	92.8	92.0	92.6	89.1	89.3	89.8	91.2	92.3	H
92.6	92.3	91.4	91.3	91.8	92.0	91.8	91.4	91.0	90.0	88.7	88.7	89.3	90.7	91.2	92.5 I
91.8	91.6	91.3	91.0	90.7	90.3	90.0	89.7	89.6	89.3	88.4	88.6	89.1	90.2	91.3	91.8 J
															K

100' ■ B.M.

88 90 92 94 96 98 96 94 92 90

ADJUSTMENT OF ENGINEER'S

PLATE BUBBLE ERROR A BUBBLE	B BUBBLE	VERTICAL X HAIR ERROR	HORIZONTAL AXIS ERROR	TELESCOPE BUBBLE ERROR
1 Division	2 Divisions	2 inches	0.1 Ft	

ORDER OF ADJUSTMENTS

1. Object. To make the plate bubbles perpendicular to the vertical axis.
Test. Level carefully and turn thru 180°. Noticed the amount of error in each bubble and recorded.
Correction Corrected ½ the error by the leveling screws and the other half by raising or lowering one end of bubble tube.

2. To make the line of collimation perpindicular to the horizontal axis.
Test. Selected point about on level with instrument at a distance of about 300 ft. Plunged telescope and set 2nd point about 300 ft. on the opposite side of instrument. Turned thru 180° and sighted again on first point. Plunged tel-

J Smith, Transit.
C Clark, Notes.
H. Jones, Flag.

TRANSIT

Feb. 14, 1914 (2 Hrs) Clear and cool.
Keuffel and Esser Transit, Locker No 9.
escope and noted the amount the
X hair missed the 2nd point as
previously set.
Correction. Moved vertical X hair
over 1/4 the apparent error
by means of X hair ring capstan
screws.

3. To make the horizontal axis ⊥ the vertical axis.
Test. Level instrument and sight at
a high point. Depressed the telescope to cover a low point. Plunged
telescope, turned thru 180° and sighted on high point again. Depressed telescope and noticed the amount line of
sight missed the low point as previously
set.
Correction. Corrected 1/2 the error by
lowering one end of the horizontal axis.

4. To make the attached bubble parallel
to the line of collimation adjust as
in 2-peg adjustment of dumpy level.

BEARING OF LINE AB WITH

OBS.	TIME	DECL.	REFRAC.	SETTING	HOR. ANGLE
1	$2^h\ 00^m$	S8°25'14.5"	1'19.5"	S8°23'55.5"	65°10.5'
2	2 15	8°25' 0.5"	1'24.5"	8°23'36"	65°10.0'
3	2 30	8°24'46.5"	1'29.5"	8°23'17"	65°10.5'
4	2 45	8°24'32.5"	1'34.5"	8°22'58"	65°11.0'
5	3 00	8°24'18.5"	1'39.5"	8°22'39.0"	65°10.5'
		Mean Angle			65°10.5'

B is West of South ∴ Bearing of line AB is S65°10.5'W

CALCULATION OF DECLINATION SETTINGS.

Latitude 41°28'. Longitude 87°04'

The Declination Tables give declination for Greenwich Mean Noon which must be corrected for time of observation.

At 2 P.M. here, it is 8 P.M. Greenwich.

Declination at Greenwich Noon Feb. 27, '14	S8°32'44.5"
Corr. for 8 hrs. = 8 X 56.25"	7'30.5"
Declination at 2 P.M. Feb. 27, 1914	S8°25'14.5"
Refraction Corr. for 2 hrs from noon	1'19.5"
Apparent Declination ("Setting")	S8°23'55.5"

For declination at other hours compute in like manner. To obtain refraction correction multiply tabular values by latitude coeff. = 1.06 for Latitude 41°28'

F. Jones, Transit
C. Clark, Flagman.
H. Smith, Notes.

SOLAR ATTACHMENT.

Feb. 27, 1914 (2 Hrs.) Clear and Warm.

Used Eugene Dietzgen Transit, Locker No 14, with Saegmuller Solar Attachment.

Used Eugene Dietzgen Solar Ephemeris.

(1) Set up over Hub A, leveling with telescope bubble. Noted index error of vertical circle and applied it to all vertical angles.

(2) Brought the telescope of solar attachment into same vertical plane as large telescope.

(3) Set off "setting" on vertical circle and leveled solar telescope by by its attached bubble.

(4) Set off co-latitude on vertical circle = $90° - 41°28' = 48°32'$

(5) Set horizontal circle at zero and sighted at A, clamped lower motion and loosened upper plate.

(6) Revolved solar attachment on its polar axis until in line with sun.

(7) Held solar attachment in this position and revolved transit telescope on its vertical axis until the solar telescope was elevated to altitude of sun. Set exactly with slow motion screws.

(8) Read hor. angle and repeated operations.

BEARING OF LINE AB BY

SUN'S POSITION	TELESCOPE	TIME	HOR. ANGLE	OBSERVED ALTITUDE	CORRECTED ALTITUDE
+	Normal	$2^h\ 0^m$	213° 40′	30° 15.5′	30° 13.8′
±	Inverted	$2^h\ 3^m$	215° 26′	30° 30.0′	30° 28.3′
Mean Values		$2^h\ 1.5^m$	214° 33′		30° 21′

Corrected Altitude = Obs. Alt. − Refr. Corr.

(1) Set up at Sta. A leveled up carefully by means of telescope bubble.

(2) Sighted at Sta. B with horizontal circle set at zero.

(3) Loosened upper plate and sighted at sun directly by means of colored glass, bringing sun's image tangent to horizontal and vertical X hairs.

(4) Read vertical circle and horizontal plate.

(5) Inverted telescope and made a second observation with sun in opposite quadrant formed by X hairs.

(6) Used the mean of the horizontal and vertical readings for position of sun's center.

(7) Corrected vertical angle for refraction.

Jas. Marnan, Transit.
F. Dusynski, Notes.
E. Malecki Flag.

DIRECT SOLAR OBSERVATION

Feb. 19, 1914 (2 Hrs.) Clear and Cool.

COMPUTATION OF BEARING OF SUN AND LINE AB.

Used Formula $\cos Z = \pm \frac{\sin D}{\cos L \cos A} - \tan L \tan A$

If result plus, angle is from N, and if minus it is from S.

D = declination. L = Latitude. A = Altitude of Sun.

The first term of second member of formula is plus for North declination and minus for South decl.

Latitude 41°28' Longitude 87°04' Feb. 19, '14.

Decl. at G.M.N. = 6 A.M. 90th Merid. S 11°28'10.8"

Corr. for 2:15 P.M. = 7.02 X 53.19" = 6'28.0"

Declination at 2:15 P.M. S 11°21'42.8"

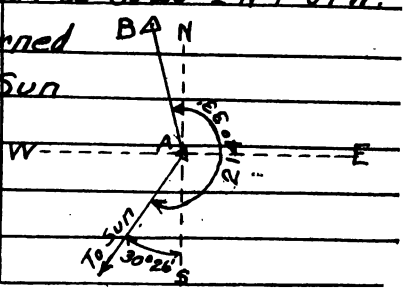
$\cos Z = - \frac{\sin 11°21'43''}{\cos 41°28' \cdot \cos 30°21'} - \tan 41°28' \cdot \tan 30°21'$

log sin 11°21'43 = 9.294480	log tan 41°28' = 9.946299
log cos 41°28' = 9.820979	" " 30°21' = 9.767545
9.473501	log 0.51742 = 9.713844
log cos 30°21' = 9.935988	0.34476
log 0.34476 = 9.537513	0.86218 = nat. cos 30°26'

Therefore Bearing of Sun is S 30°26' W.

Bearing of line = 180° − (214°33' − 30°26') = N 4°07' W.

Note: Angle was turned clockwise from B to Sun



BEARING OF LINE AB BY

OBS	TELESCOPE	TIME	HORIZONTAL READING	CORR. FOR TIME=.058t	CORRECTED AZ. OF POLARIS	HOR. ANG. FROM N.
	Nor.	$9^h 00^m$	60° 05′	0° 0.0′	1° 32′.0	61° 37′.0
2	Inv.	$9^h 05^m$	60° 05.5′	0° 0.0′	1° 32′.0	61° 37′.5
3	Nor.	$9^h 10^m$	60° 05.5′	0° 0.1′	1° 31.′9	61° 37′.4
4	Inv.	$9^h 15$	60° 06.0′	0° 0.2′	1° 31.′8	61° 37′.8
			Mean Angle from North			61° 37′.4

B is West of North ∴ AB bears N 61° 37′.4 W.

CALCULATION OF TIME OF WEST. ELONGATION

Latitude 41° 28′ N. Longitude 87° 04′ W

Mean time of U.C. Polaris Feb. 15, 1914	$3^h 48^m.7$
Corr. for 8 days = 8 × $3^m.95$ =	$31^m.6$
Mean time of U.C. Polaris Feb. 23, 1914	$3^h 17^m.1$
Corr. for Long. 87° 04′ = 3 × 4^m =	$12^m.0$
Standard time U.C. Polaris Feb. 23, 1914	$3^h 05^m.1$
For Western Elongation add	$5^h 55^m$
Standard time W.E. Polaris Feb. 23, 1914	$9^h 00^m.1$

CALCULATION OF AZIMUTH OF POLARIS

Azimuth at Elongation for Lat. 41°	1° 31′.3
" " " " " 42°	1° 32′.7
Diff.	0° 1′.4
Correction for Lat. 41° 28′ = $\frac{28}{60}$ × 1′.4 =	0′.7
Azimuth at Elongation for Lat. 41° 28 =	1° 32′.0

H. Smith, Transit
C. Clark, Notes
F. Jones, Flagman.

POLARIS AT ELONGATION

Feb. 23, 1914 (2 Hrs) Clear and Cool
Keuffel and Esser Transit, Locker No 9.
Set watch at correct standard time before going out to field.
Set up at Sta. A and leveled carefully.
Sighted to B with vernier set at zero.
Held light close to object end of telescope to illuminate X hairs when sighting.
Loosened upper plate and sighted at Polaris
When Polaris appeared to move along vertical X hair noted time and read horizontal angle. Inverted telescope and sighted on Polaris and read the horizontal angle.
Repeated the above operations and corrected Azimuth of Polaris by formula $0.058t^2$, where t = time from elongation in minutes and the result is the correction in seconds of arc.

DETERMINATION OF LATITUDE

DATE	TIME	DECL.	VERT. ANGLE		
Feb. 27 '14	11h 48m A.M.	S 8° 27' 07"	48° 32'		
Latitude = 90° − 48° 32' = 41° 28'					

CALCULATION OF DECLINATION.

Assumed Latitude to be 41° 30'

Longitude 87° 04'

Declination at Greenwich Noon Feb 27, '14. S 8° 32' 44.5"

At Greenwich noon it is 6:00 A.M. here,

∴ correction is 6 × 56.25" = 0° 5' 37.5"

Decl. at mean noon for 90th Merid. S 8° 27' 07"

Since Valparaiso is approximately 3° East of Standard Meridian, the sun crosses our South point at 3 × 4m earlier or at 11h 52m A.M. by standard time.

WITH SOLAR ATTACHMENT.

Feb. 27, 1914 (2 Hrs.) Clear and Cool.

(1) Leveled carefully and brought the two telescopes into same vertical plane.

(2) Set off on vertical circle the declination of the sun as found in the solar ephemeris.

(3) Leveled solar telescope by means of its attached bubble. Did not disturb the vertical angle between solar telescope and main telescope until end of observation.

(4) Turned main telescope on its horizontal and vertical axes until sun appeared between the horizontal X hairs, and kept it so until sun ceased to rise.

(5) Read vertical angle which = co-lat. Then latitude = 90° − co-latitude.

TO-LOCATE-A-SIMPLE

Given a simple curve with $I = 5°$, $D = 5°$ and PC at Sta. 247+40

$\sin \frac{1}{2} D' = \frac{\frac{1}{2} C'}{R} = \frac{\frac{60}{30}}{1146.28} = \frac{30}{1146.28} = 1°94'$

$D' = 3°$

$t = 2C \sin \frac{1}{4} D = 200 \sin 1°15'$

$t = 4.367$

$t' = 2C' \sin \frac{1}{4} D'$

$t' = 1.57$

$100 : 60 = 1.57 : x$

$x = \frac{157}{60} = 2.61$

$d = 2C \sin \frac{1}{2} D$

$= 200 \sin 2°30$

$= 8.724$

$L = \frac{I}{D} = \frac{26°}{5°} = 5.2$ Sta.

$PT = 247+40 + 5+20 = 252+60$

$LC = \frac{L.C.}{D} = \frac{2578}{5} = 515.6'$

$L.C. = 2R \times \sin \frac{1}{2} I$

$= 515.83'$

CURVE - WITH - TAPE.

June 5. '12 (2 Hrs) Fair and Warm

Used two methods in running the curve. First by computing offsets from chords produced. Second by offsets from the long chord. The curve was run in by first method, and the position of the P.T. was checked by measuring the long chord.

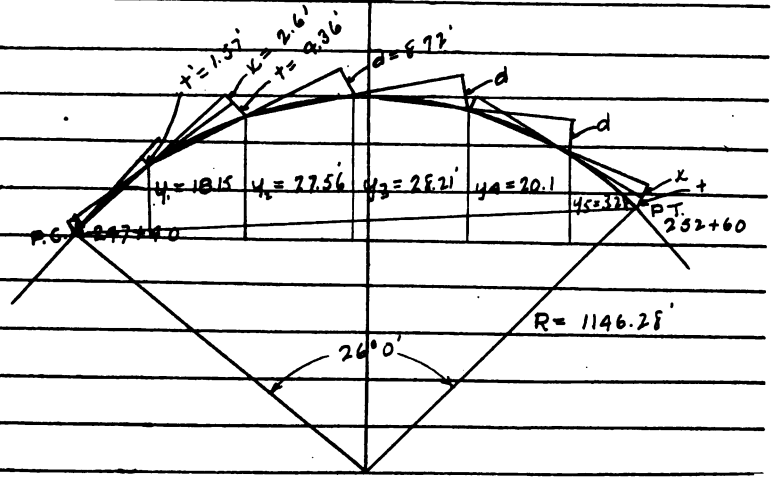
II METHOD

$$y = \frac{7}{8} mnD$$

$y_1 = \frac{35}{8} \times .6 \times 4.9 = 18.15'$, $y_2 = \frac{35}{8} \times 1.6 \times 3.9 = 27.56$

$y_3 = \frac{35}{8} \times 2.6 \times 2.9 = 28.21'$, $y_4 = \frac{35}{8} \times 3.6 \times 1.9 = 20.12$

$y_5 = \frac{35}{8} \times 4.6 \times .9 = 3.28'$



TO-LOCATE-A-SIMPLE-CURVE

STATION	DEFLECTION ANGLE	INDEX READING	TOTAL ANGLE	REMARKS
127+25.80	0°0'	0°0'		P.C.
128+00	1°52'	1°52'		
129+00	2°30'	4°22'		5° Curve Right
130+00	"	6°52'		I = 26°
131+00	"	9°22'		T = 264.64
132+00	"	11°52'		
132+45	1°8'	13°0'	26°	P.T.
133+00				

$$\sin \tfrac{1}{2} d = \frac{\frac{c}{2}}{R} = \frac{87.5}{1146.3} = .03272$$

$$d = 1°52'$$

$$T = R \tan \tfrac{1}{2} I$$

$$= 1146.6 \times \tan 13°$$

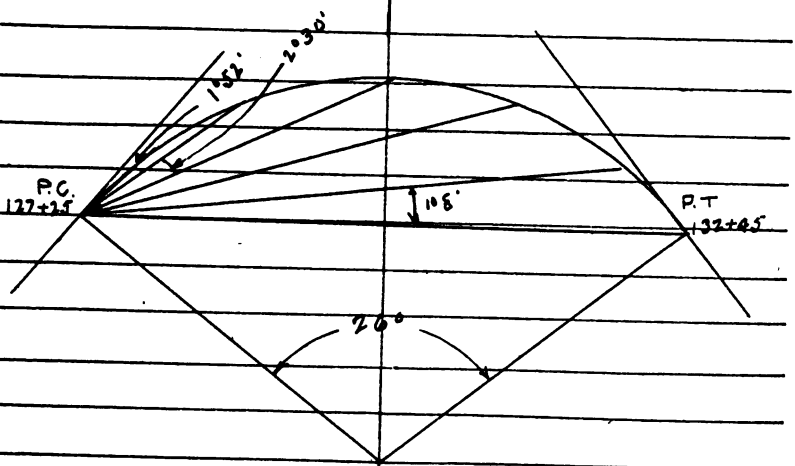
$$= 1146.6 \times .23087$$

$$= 264.64$$

WITH-TRANSIT-AND-CHAIN.

June 12, '12 (2 hrs). Fair and Warm.
Used K. & E. Transit, Chain, flag poles
Locker #14

The curve was located by setting up transit at PC and backsighting on tangent. The stations were located by laying off sucessive deflection angles, and measuring sucessive chords.



TO-LOCATE-A-SIMPLE-CURVE

STATION	DEFLECTION ANGLE	INDEX READING	TOTAL ANGLE	REMARKS
139+00				
140+00				
141+00				
141+25	0° 0'	0° 0'		P.C.
142+00	1° 30'	1° 30'		
143+00	2° 0'	3° 30'		
144+00	"	5° 30'		4° C. RIGHT.
145+00	"	7° 30'		I = 27°
146+00	"	9° 30'		AH = 889.63'
147+00	"	11° 30'		
148+00	"	13° 30'	27°	P.T.

$T = \frac{T.}{4} \times 27° = 343.9'$ or $T = R \tan \frac{1}{2} I = 1432.69 \times \tan$

$13°30' = 343.84'$

$AC = AB + BC = 568.9'$ $CH = 343.9'$

$\frac{\tan \frac{1}{2}(n-a)}{\tan \frac{1}{2}(n+a)} = \frac{AC - CH}{AC + CH} = \frac{568.9 - 343.9}{568.9 + 343.9} = \frac{225}{912.8}$

$\tan \frac{1}{2}(n-a) = \frac{225}{912.8} \times \tan 13°30'$, $\frac{1}{2}(n-a) = 3°23'40''$

$\frac{1}{2}(n-a) + \frac{1}{2}(n+a) = n$, $\frac{1}{2}(n-a) - \frac{1}{2}(n+a) = a$

$n = 3°23' + 13°30' = 16°53'40''$, $a = 10°6'20''$

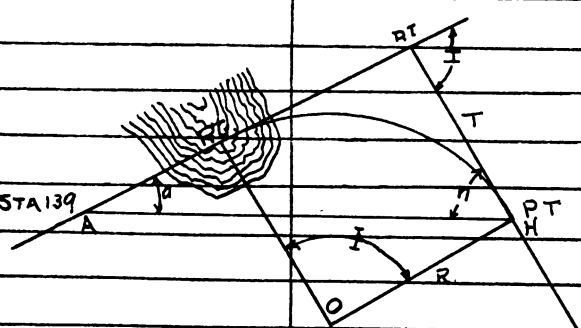
$AH = 343.9 \frac{\sin 27°}{\sin 10°6'} = \frac{343.9 \times 4.59}{1.755} = 889.63$

T. BROWN, NOTES.
R. SMITH, TRANSIT.
J. JONES, CHAIN.

VE WHEN THE P.C. IS INACCESSIBLE.

June 17, '12, (2 Hrs) Warm and Cloudy.
Used transit, tape, pins & range poles,
Locker # 13.

It is desired to locate a curve when the P.C. is inaccessible. Sta. 139+00 on the tangent was chosen, from which to run a line to the P.T. at sta. 148+00. In order to do this it was necessary to calculate angles (a) and (b) and side AH. The transit was set up at A, angle (a) layed off from initial tangent, line AH measured. From point H angle (b) was layed off from AH and final tangent located. The curve was then run in backwards.



TO-LOCATE-A-SIMPLE-CURVE

STATION	DEFLECTION ANGLE	INDEX ANGLE	TOTAL ANGLE	REMARKS
200+00	0° 0'			P.C.
201+00	1° 0'			
202+00	"			
203+00	"			
204+00	"			D = 2° RIGHT
205+00	"			I = 11°
205+50				Pt F = Sta 206+91
206+00				
206+91				

$T = R \tan \frac{1}{2} I = 2864.93 \times \tan 5°30' = 275.96'$

ANGLE C = 90°, f = 80°, side EF = 310'

$\frac{EF}{CF} = \frac{\sin c}{\sin e}$ — $CF = EF \frac{\sin e}{\sin c}$

$CF = \frac{310 \sin 60°}{\sin 40°} = 417.7'$

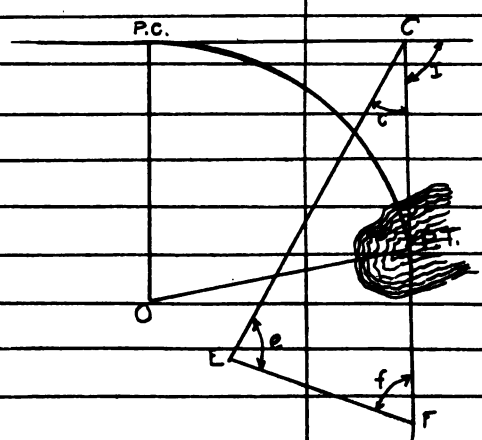
∴ Point F = 206+91.83'

WHEN-THE-P.T. IS-INACCESSIBLE.

June 22. '12 (2 Hrs) Warm & Cloudy.

Used Gurley Transit Locker # 7.

It is desired to pass a tangent when the P.T. is inacessible. In order to do so it was necessary to locate the P.I. and from this a random line was ran to some point E; point E was then located in the final tangent and angle (f) and side EF measured. By trigonometry side CF was calculated and sta number of point F was then found.



TO-LOCATE-A-COMPOUND-CURVE-

STATION	DEFLECTION ANGLE	INDEX ANGLE	TOTAL ANGLE	REMARKS
110+00	0° 0	0° 0'		P.C.
111+00	2° 0'	2° 0'		
112+00	"	4° 0'		
113+00	"	6° 0'		
114+00	"	8° 0'		
114+58.8	1° 46'	9° 46'	19° 32'	P.C.C.
115+00	0° 23.2'	0° 23.2'		Setupover P.C.C
116+00	3° 10.5'	3° 33.7'		backsighted to
117+00	"	6° 44'		PC and got on
118+00	"	9° 55'		tangent by
118+58	1° 49.3'	11° 44'	23° 28'	P.T laying
				off 9° 46'. From
				this tangent the
				deflection angle
				to locate sta
				119+00 was layed
				off

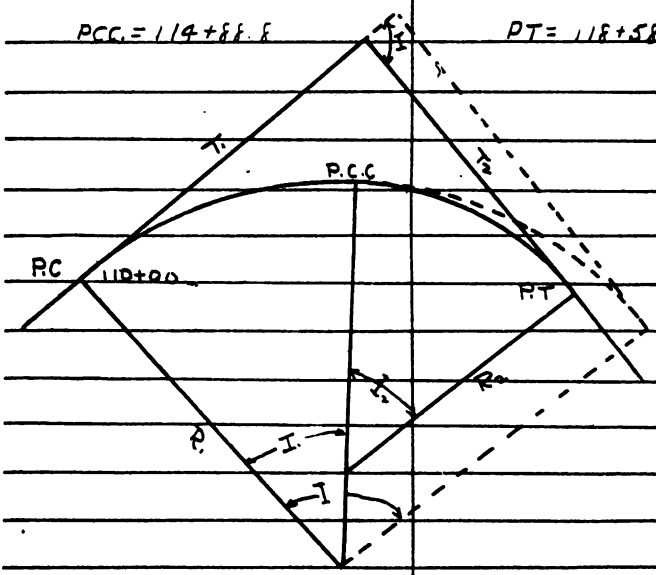
WITH-TRANSIT-AND-CHAIN.

June 27, '12 (1½ Hrs.) Fair and Warm.

Used Dietzgen Transit Locker #13.

The curve was run in as two simple curves. The deflection angles and index angles were computed as separate curves.

$R_1 = 1432.7'$	$R_2 = 401.'$
$D_1 = 4°$	$D_2 = 6°21'$
$I = 43°$	$I_2 = 23°28'$
$T_1 = 500'$	$I_1 = 19°32'$
$LC_1 = 488'$	$T_2 = 400'$
PC = 110+0	$LC_2 = 584.2$
PCC = 114+88.8	PT = 118+58



TO-LOCATE-A-TRANSITION-

STATION	POSITION	OFFSET	REMARKS		
410+30.1	P.T.C	0	Offset from tangent		
410+72.6	$\frac{1}{8}$ Point	0.033	" "	"	D=5°
411+15.1	$\frac{1}{4}$ Point	0.26	" "	"	I=90°
411+57.6	$\frac{3}{8}$ Point	0.89	" "	"	I_1=8.5°
412+00	Mid Point	2.1	" "	"	
412+42.6	$\frac{5}{8}$ Point	0.89	Offset from circular curve		
412+85.1	$\frac{6}{8}$ Point	0.26	"	" " "	
413+27.6	$\frac{7}{8}$ Point	0.033	"	" " "	
413+70.1	PC_1	0	"	" "	

- OFFSETS -

AT MID POINT STA 412 $t = \frac{4.2}{2} = 2.1'$

" ONE EIGHTH POINTS STAS. $\begin{cases} 410+72.6 \\ 413+27.6 \end{cases}$ $t = 2.1 \times (\frac{1}{4})^3 = 0.033$

" QUARTER " STAS. $\begin{cases} 411+15.1 \\ 412+85.1 \end{cases}$ $t = .033 \times 2^3 = 0.26$

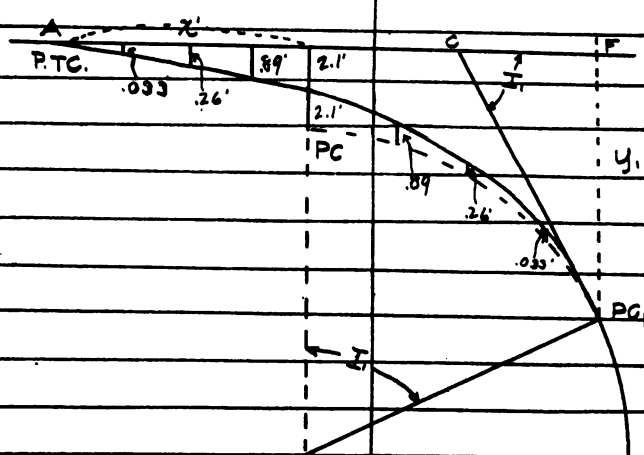
" THREE EIGHTH " STAS. $\begin{cases} 411+57.6 \\ 412+42.6 \end{cases}$ $t = .033 \times 3^3 = 0.89$

CURVE-BY-OFFSETS.

June 27. '12 (1½ Hrs) Warm and Cloudy

The transition curve was layed out by means of offsets, measured from tangent at the P.T.C. up to the mid point and the other half from the circular curve back from the P.C.

The offset (F) of the circular curve was given as 9.2' from which the length of the transition curve was found to be 340' by the table. From the table x' was found to be 169.9', $I_1° = 8.5'$, and the excess of curve over tangent as .02'.



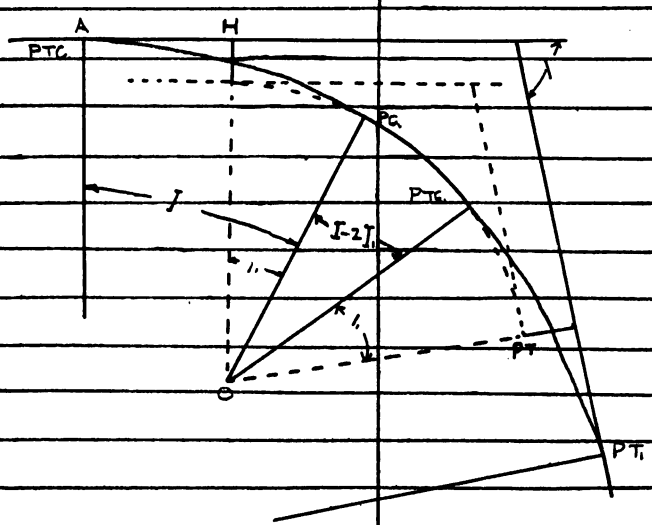
TO-LOCATE-A-TRANSITION

		DEFLECTION ANGLE	CENTRAL ANGLE	REMARKS	
158+00					
159+00					
159+50	P.T.C.	0°0'	4°0'	D = 4°	
160+00		0°5'		l_1 = 200'	
160+50		0°20'		I = 20°	
161+00		0°45'		I_1 = 4°	
161+50	P.O.	1°20'	12°0	x' = 100'	
162+00		1°0'		Set ver. at 2°40'	
163+00		3°0'		B.S. to 159+50 and	
164+00		5°0'		deflect to 0° Run	
164+50	PTC.	6°0'	4°0	circular curve	
165+00		0°55'			
165+50		1°40'			
166+00		2°15'			
166+50	PT.	2°40			
167+00					

CURVE-BY-DEFLECTION-ANGLES.

July 2, '12. (1½ Hrs) Fair and Warm.

A 200' transition curve was chosen from which F, I_1, and v' were found in the table. The two transition curves were divided into four stations of 50' each. The deflection angle were then calculated. The first transition curve was run in by deflection from the tangent at PTC. The portion of the circular curve was run by deflections from tangent at PC_1. The second transition curve was run in by deflections from tangent at PTC_1.



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